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REPORT OF THE SUPERINTENDENT

OF THE

UNITED STATES COAST SURVEY,

SHOWING

THE PROGRESS OF THE SURVEY

DURING

THE YEAR 1874.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1877.

LETTER

FROM

THE SECRETARY OF THE TREASURY,

TRANSMITTING

REPORT OF THE SUPERINTENDENT OF THE COAST SURVEY.

TREASURY DEPARTMENT, *January* 13, 1875.

SIR: I have the honor to transmit, for the information of the House of Representatives, a report made to this Department by Carlile P. Patterson, Superintendent of the Coast Survey, stating the operations and progress in the survey of the coast during the year ending June 30, 1874.

I have the honor to be, very respectfully,

B. H. BRISTOW,
Secretary of the Treasury.

Hon. JAMES G. BLAINE,
Speaker of the House of Representatives.

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REPORT.

UNITED STATES COAST SURVEY OFFICE,
Washington, September 15, 1874.

SIR: I have the honor to submit, with this report on the progress made during the year ending June 30, some remarks on the condition of the Coast Survey, and suggestions for maintaining a steady rate of progress in the work.

When appointed as Superintendent, on the 17th of February last, after having been, during the preceding thirteen years, Hydrographic Inspector of the Coast Survey, I found that, with the assured co-operation of the late Superintendent, Professor Benjamin Peirce, for needful consultation in scientific matters, my only duties, additional to hydrographic details, would be those of careful direction and administration. The methods, processes, and formulæ established and perfected by the three eminent men Hassler, Bache, and Peirce, who have preceded in the charge of the work, the last being the acknowledged mathematical chief of our country, leave nothing to be added to their theoretical construction and values, and but little in the way of constants and refinements as likely to be developed by further advances in science.

The directive and administrative duties as now extended, call for the almost exclusive attention and time of the Superintendent, in order to insure proper results and due economy. The work requires such assistance as the most advanced science of the country can afford, and this requisite is met by a number of able assistants, and by the hearty co-operation of all the leading scientific men of the nation.

The several divisions and classes of the work, which have grown from the small beginning on the south beach of Long Island in 1832, until they now spread their utilities and benefits in twenty-eight States and Territories, will be adhered to.

In the early years of the Survey, field-operations being then restricted to the vicinity of New York Bay, and the working-season consequently from April to December, the custom arose to report the operations for the year ending with November. At present, however, as for some years past, field-work is prosecuted continuously at the North during the summer and on the Southern coast during winter. It has been found impossible to receive field-reports from distant parties, some being on the coast of Washington Territory, and one of them on the coast of Alaska, in time to include mention of their results in a report annually closed and presented in December. I have, therefore, substituted the end of the fiscal year for the closing date; and this report will conform to what has been general usage in regard to annual statements from other branches of the public service. The report now submitted will notice in detail the work done last winter and spring, and will mention also the allotment of parties for the work of the early part of the present fiscal year.

In explanation of the estimates submitted for the Coast Survey, both in relation to the annual expenditures and the vessels required, I have the honor to state, that when placed in charge of the Coast Survey, in February last, I found that my predecessor had submitted estimates for the present fiscal year, based upon the strictest principles of the relations between economy of expenditures and largeness of results, and predicated upon a policy indorsed by Congress through a series of years. These estimates, in the aggregate $825,000, were reduced by Congress (in the general policy at that time so needful) in its appropriations to but $706,000 for the regular work of the Coast Survey, a decrease of $119,000, or 14½ per cent. below the amount of the estimates. This reduction

has necessarily restrained me from the execution of much work greatly wanted, but now postponed to the next fiscal year. All the omitted work of this year, as well as the work due to the next, must be executed in the coming year to place the Coast Survey in the position it would have occupied had the appropriation of this year equaled the estimates so carefully prepared and submitted by my predecessor.

One of my first duties after being appointed was to make a careful investigation and estimate of the amount of work yet to be done to complete the survey of our now actual coasts; to compare this amount with that already executed, as well as the time consumed in the latter with that estimated to be necessary in the former.

A comparison of the actual spaces covered by the various classes of work now finished and those to be done would not yield a true ratio of their respective times; for at first the Coast Survey had, from the necessity of the case, to be commenced on a very limited scale, and many years had to elapse before a full organization could obtain, and the work be carried forward from many centers, in the several sections of both coasts, by trained officers. In fact, the organization, the methods, and the officers had to be created by the eminent men who have preceded me. The splendid results justify their work.

In 1832, when the Coast Survey really made a beginning, Texas and California, with fifteen hundred miles of sea-coast, and more than four times that number in harbor-lines and island-shores, as also Alaska, with its enormous length of ocean-shore, were foreign territories.

For ten years, the work necessarily advanced tentatively and slowly, and subsequently, having received the indorsement of the highest scientific and practical authorities in both this country and Europe, was fully approved by Congress, which, during the years 1856, '57, '58, '59, and '60, made such increased appropriations as utility and economy demanded.

In 1842, the work of the Coast Survey was being executed in four States.

In 1874, the Coast Survey, thoroughly organized, is working in twenty-four States and two Territories, and capable of producing, with its present constants of expense, the largest amount of and most economical results.

In face of the difference in the value of money, the average salaries of assistants and subassistants in 1874 is no greater than in 1842.

The experience of the Coast Survey now admits of a very close estimate of the time and means required to complete the survey of our now actual coast. I have carefully gone over the finished and unfinished work of the Coast Survey, compared cost and time, and find the Coast Survey has been at work for forty-two years, and that two thirds of the coast have been surveyed, exclusive of Alaska.

I conclude, after making due allowance for unforeseen delays, that the survey of the now actual sea-coast of the United States remaining unsurveyed can be completed in twelve years if the moderate means asked for are supplied. These means are but the restoration of the *value* of the annual appropriation to that of the average of the years 1856 and '57, '57 and '58, '58 and '59, '59 and '60, with two more vessels than were at that time in the Coast Survey. A comparison of the actual cost in number of dollars of any class of work in 1858 and 1874 is no measure of relative economy.

The following statistics give the cost for a number of articles and rates of wages and compensation between the periods 1854–'58 and 1869–'74, as taken from official printed documents:

Prices of several articles in New York in the years 1858 *and* 1873.

Articles.	1858.	1873.	Increase.
			Per cent.
Wheat-flour .... per barrel..	$3 80	$4 95	30
Coffee, Rio .... per pound..	10½	19	80
Copper bolts .... do....	22	40	80
Cotton, middling .... do....	12	21	75
Cod-fish, dry .... per cwt..	2 93	6 25	113
Iron, Scotch pig .... per ton..	23 00	47 48	108
Iron, common English .... do....	45 75	97 50	113
Molasses, New Orleans .... per gallon..	39	68	74
Tea, Young Hyson .... per pound..	36	57	58
Rice .... per cwt..	3 30	8 12	146
Salt .... per sack..	74	2 40	210
Average increase of these articles, including beef and pork as the same..........			83

Beef and pork fluctuated greatly in price from month to month, but averaged about the same.

The average increase of cost of materials and labor for a dwelling-house suitable for workmen equals 80 per cent.

Weekly wages in New York in the years 1860 *and* 1869.

	1860.	1869.	Increase.
			Per cent.
Blacksmiths	$12 00	$20 00	66
Boiler-makers	10 00	18 00	80
Brass-founders	14 00	21 00	50
Carpenters	13 50	24 00	78
Cartmen	9 50	16 50	52
Coopers	10 50	22 00	109
Engineers	12 00	24 00	100
Laborers	6 50	12 50	92
Iron-molders	10 00	18 00	80
Machinists	12 00	16 50	37
Painters	12 00	22 50	87
Plumbers	13 50	21 00	55
Seamen—Navy wages of seamen have been increased from time to time from $12 per month in 1854 to $21.50 per month in 1874			79
Average increase of all these items			85

Average increase of seven other classes of wages in five States equals 71 per cent.

Average cost per ton in Baltimore of a merchant-vessel's hull and spars in 1858 equals $24.50; in 1874, $53; an increase of 116 per cent.

From these data, it is quite evident that money—gold as well as notes—has depreciated greatly in value, and that the present currency has not more than three-fifths the power of getting work accomplished or the purchasing value of the currency of 1858. The average appropriation for the Coast Survey for the years 1856 and '57, '57 and '58, '58 and '59, '59 and '60, was $537,000, equal in value to $895,000 in 1874. The appropriation for 1874–'75 is, for the regular work, but $706,000 equal in value to about $423,600 in 1858, or about 27 per cent. less in value than the average appropriations for the years above named.

To the work of the Coast Survey in its earlier years, others—its natural outgrowth—have been added, for which appropriations have been made and are now estimated for, in addition to the classes of work for which appropriations were made in 1858. Deducting these portions of the appropriation from the total, the aggregate amount estimated for the year 1875 and '76 would be less in value than the average appropriations for the years 1856 and '57, '57 and '58, '58 and '59, '59 and '60, by $140,000, or more than 16 per cent. less than the estimates submitted.

With an increase of 25 per cent., the results can be increased 65 per cent.; for, as the constants of expense for the whole work remain nearly the same, almost the entire additional amount can be applied directly to field-work and to the production of charts and maps.

VESSELS.

In the years 1856 and '57, '57 and '58, '58 and '59, '59 and '60, the Coast Survey, by the genius of Hassler and Bache, had developed into a fixed organization, for the support of which Congress made almost constant equal appropriations, averaging for these former years $537,000 per annum.

The war, by withdrawing the naval officers, who had by law, when they could be supplied by the Navy Department, the execution of the hydrography, added to which many of the civil assistants of the work were employed as topographical officers to several corps of the Army operating in different parts of the country, disarranged this organization. Although the system of the organization was thus materially interfered with, the work continued upon its old basis, notwithstanding various efforts made by my predecessor since the close of the war to restore the conditions of the organization as it existed in the years referred to before the war; but from the want of sufficient appropriations to supply the deficiencies in the number of vessels, the inability of the Navy Department to furnish the required number of officers, and other causes, the restoration of the conditions referred to has not been possible.

The law requires that the hydrography of the Coast Survey shall be executed by officers and men of the Navy when they can be furnished.

It is my duty, and I am most anxious, to carry this law fully into effect, and the Navy Department now stands ready to supply the required complements; but there is a great deficiency of vessels forthe purpose, and estimates are submitted for but two vessels more than Congress deemed necessary in 1858. It has been officially stated in letters, from the honorable Secretary of the Navy and from the Treasury, that no vessels of the classes required for Coast-Survey work can be supplied, either from the Navy or from the Revenue Marine.

The absolute necessity for more vessels for the rapid execution of the work is evident from the following comparison; only two more than were used in 1858 being estimated for:—

In 1858, the Coast Survey had five sea-going steamers on the Atlantic and Gulf coasts.

In 1874, there are but two, with one building. Estimates for two more are submitted to raise the number to that of 1858.

In 1858, the Coast Survey had twenty-five schooners and small steamers on the Atlantic and Gulf coasts. In 1874, there are twenty-four.

In 1858, before the work was fully organized there, the Coast Survey had on the Pacific coast one sea-going steamer and three schooners, quite sufficient then for the scale of work upon that coast. In 1874, there are one sea-going steamer and three schooners, two of them too old and decayed to be trusted at sea. In the last few years, under the direction of my immediate predecessor, this portion of the work has rapidly progressed; but, from want of vessels, the shore-work has advanced greatly beyond the hydrography, and now over three hundred miles of the land-work of the coast is finished, awaiting the completion of the hydrography in order that maps and charts may be issued. This hydrography can, of course, only be accomplished by vessels, which the Coast Survey has not, nor the means to obtain them.

In 1858, all the vessels were comparatively new, none being over eight or nine years old.

In 1874, there are twelve from eighteen to twenty-five years old, rotten, worn out, and worthless, utterly valueless for any use, reducing the available number to nineteen, compared to thirty-four in 1858.

With the number of vessels estimated for, and the sale of the twelve useless ones, the total number of vessels in the Coast Survey would be thirty-six; the total in 1858 having been thirty-four. The number of vessels on the Atlantic and Gulf coasts will be decreased; the number on the Pacific coast will be increased; but the total number for all coasts will be but two more than in 1858. Without some unexpected casualties, no more special appropriations for the construction of vessels will be required to complete the survey of the present limits of the coasts of the United States; and appropriations for those for which estimates are submitted are urged from the positive necessities of the work; and, besides, it must be considered that a full year must elapse after the appropriation becomes available before the vessels can be ready for use.

The average receipts from the customs for the years 1857, '58, '59, and '60 were $52,106,740.56. In 1873, these receipts were $188,089,522.70, or 261 per cent. increase in gold.

The increase of Coast Survey appropriation, reduced to gold, is but 11 per cent.

Although these relative amounts are not entirely logical as bearing on the appropriation for the Coast Survey, yet they tend to show with what rapidity our external commerce has increased and is increasing, amassing, with the coastwise trade, figures which but a few years ago would have been deemed incredible; and they also tend to show the imperative necessity of completing the survey of our coasts in the shortest possible time consistent with proper economy and due accuracy of work.

The same ratio of appropriation for the Coast Survey to the custom-receipts in 1874 and '75 as obtained in 1858 would give $1,938,570, or more than 100 per cent. over the amount for which estimates are submitted.

The enormous extent of the coasting-trade along the coasts of the United States, now estimated to exceed forty millions of tons transported per annum, demands for its greater security the speediest completion of the work, as is evidenced from the constant calls upon the office for detailed charts and sailing-directions of those ports of the coast not yet surveyed. The estimates submitted are based upon the actual necessities of the work, the constantly increasing demands for charts of the unfinished parts of the coast, and the value of the average appropriations made by Congress in the years 1856 and '57, '57 and '58, '58 and '59, '59 and '60, after years of trial, deliberate investigation, full

discussion, and mature judgment. The work is essentially temporary in character, the number of miles of coast known, the cost and time for completion a mere question of arithmetic.

The present purchasing value of currency is not more than three-fifths of that in the years above named. The average appropriations for these years was $537,000, and that amount is three-fifths of $895,000 for work of the classes executed in 1858. To this add $140,000 for work since added and required, and we have a total of $1,035,000; the total amount estimated for is $893,000; less by $142,000, or 14 per cent.

The work cannot proceed with proper economy and speed without a proper supply of vessels, and estimates for but two more are submitted than are required to restore the efficient number actually in the Coast Survey in 1858. With all the vessels completed for which estimates are submitted, there will be required, in addition to the regular estimates submitted for the year 1875 and '76, about $75,000, or a total of $968,000, with which annual appropriation the whole survey of the coast can be completed in twelve years; leaving no further work to be executed except the publishing of charts, results of the work, and the resurveying of the changeable harbors and portions of the coasts, which would involve no great expense.

Good charts, light-houses, and buoys, by rendering navigation safe, reduce the expenses of insurance, detention, pilotage, etc., and thus cheapen transportation. In the coasting-trade alone, of 40,000,000 tons, valued at only $20 per ton, equal to $800,000,000, if the expenses of its transportation are reduced by one per cent. upon its value, we have a sum of $8,000,000 per annum saved, or double the annual cost of the Coast Survey and light-house system combined, or over eight times the cost of the Coast Survey, if its annual cost was to be ceaseless, instead of ending in twelve years.

Feeling confident that Congress wishes the speedy termination of this work as a measure of necessity to our enormous and constantly increasing commerce, as well as a matter of general utility and economy, and trusting for its approval, I have deemed it my duty to submit these estimates for the most rapid and economical completion of the survey of the coasts of the United States.

In the detailed estimates, the work for the fiscal year ending June 30, 1876, will be stated in geographical order, beginning on the Atlantic coast of the United States at the northeastern boundary, and terminating on the coast of Texas. On the Pacific coast, the sites will be named in the reverse order, beginning at San Diego and terminating with the coast of Alaska. As a practical illustration of the estimates, an abstract is here presented, showing the sites in which the field-work and hydrography are now in progress, and including mention also of the localities in which the same parties worked during last winter and spring in the southern sections of the Atlantic and Pacific coasts, and on the Gulf coast of the United States. The recapitulation includes, as the operations now in hand:—deep-sea soundings in the Gulf of Maine between Nova Scotia and Cape Cod; topography of Mount Desert Island, and soundings in its vicinity; detailed survey of the shores of Eggemoggin Reach; of islands east and west of Deer Isle and Isle au Haut; of the eastern shore of the Penobscot, between Castine and Bucksport; hydrography at the head of Penobscot Bay; determinations of height and of the co-efficient of refraction at the primary station near Camden, Me.; tidal observations at North Haven, Penobscot Bay; hydrography of the vicinity of Jeffrey's Ledge, Cashe's Ledge, and Jeffrey's Bank, including surface and deep-sea temperatures; determination of geographical points by triangulation in New Hampshire; tidal observations at Boston navy-yard; special observations and topographical survey near North Adams, Mass., for determining differences in the intensity of gravitation; hydrography of the vicinity of Monomoy, coast of Massachusetts; special test of sailing-courses in Narragansett Bay, for the Coast Pilot; detailed survey of the shores and soundings in Taunton River, Mass.; shore-line survey and soundings, with observations on tides and currents in Providence Harbor, R. I.; detailed survey and soundings in Thames River, Conn., above the navy-station at New London; topography of the shores of New Haven Harbor; positions of light-houses determined at the eastern entrance of Long Island Sound, N. Y.; hydrographic development of the channel westward of Plum Island; special observations on tides and currents in the waters of New York Bay and Harbor; development of a shoal in the Swash Channel off Sandy Hook; shore-line survey and soundings at Port Jefferson, Long Island; tidal observations continued at the station on Governor's Island near New York City; reconnaissance for determining points eastward of Hudson River, and between Albany and Lake Champlain; shore-line survey and hydrography of Lake

Champlain, from previous limits of work southward to Whitehall; latitude and azimuth determined at Rouse's Point, Crown Point, and Hudson, N. Y.; shore-line survey and soundings continued in Great South Bay, Long Island; magnetic declination, dip, and intensity determined at Ithaca and Oxford, N. Y., at Bethlehem, Penn., and at Cape May, N. J.; detailed survey of the shores of Barnegat Bay and soundings in its southern branch; hydrography of the bar at Little Egg Harbor, N. J.; latitude and azimuth observed at Keyport and Barnegat, N. J.; positions of light-houses determined at Cape May, and in Delaware Bay at Maurice River, Mispillion Creek, and Hereford Inlet. Earlier in the year, the same parties made progress by surveys on the southern coast and its waters, and these include:—examinations of sailing-courses in the harbors of Chesapeake Bay, and compilation of notes for the Coast Pilot; the topography of Marbury Point, D. C., including site for the United States naval magazine; supplementary plane-table work along the east side of the Potomac at Washington and Bladensburgh; determination of the magnetic elements at Washington City; local triangulation of the Upper Potomac connected at Sugar Loaf Mountain, Md., with primary triangulation in Virginia; determination of points by triangulation (yet in progress) along the Blue Ridge in Virginia; reconnaissance (yet in progress) for stations between Staunton, Va., and the Ohio River; detailed survey of the shores and soundings in James River, Va., from Warwick River entrance upward to Sandy Point, including the lower part of the Chickahominy; topography of Norfolk, Portsmouth, and Gosport; shore-line survey and hydrography of Nansemond River, Va.; development of the channel between Craney Island and the mainland; inspection of plane-table operations in the field; tidal observations at Fortress Monroe; sailing-courses south of Cape Henry, Va., determined for passing the Lookout and Frying Pan Shoals, and additional notes for the Atlantic Coast Pilot; triangulation (yet in progress) in Pamplico Sound; triangulation, plane-table survey, and hydrography of Chowan River, Albemarle Sound, N. C.; detailed survey of the north shore of Pamplico Sound in the vicinity of Swan Quarter Bay; hydrography of Pamplico Sound westward of Gulf Shoal Rock; soundings in Pungo River; inspection of the plane-table operations; hydrography of Beaufort Bar, N. C., including the approaches, the harbor, North River, and Newport River; soundings in the western channel of Cape Fear River, and development of changes in that vicinity; detailed survey of the coast of South Carolina near Cape Romain, including Oyster Bay; harbor-entrances between Winyah Bay and Savannah River examined for sailing-courses and notes for the Coast Pilot; shore-line survey, hydrography, and special observations on the currents of Savannah River, Ga.; astronomical observations at Savannah for determinations of longitude by the telegraphic exchange of clock-signals; inspection of plane-table operations in this section north and south of Charleston, S. C.; hydrography of Fernandina Bar and its approaches, and of the Atlantic coast below Saint John's River entrance; detailed survey of Halifax and Hillsboro Rivers, including Mosquito Inlet and the adjacent coast of Florida; astronomical observations at Key West for determining longitude by clock-signals; determination of longitude at the entrance to Charlotte Harbor, Fla.; triangulation and topography advanced on the east side of Tampa Bay, including Manatee River; hydrography of Tampa Bay from the Gulf entrance upward to Mangrove Point; inspection of the plane-table operations in the same quarter; longitude determined at Cedar Keys, Fla., and at a station near Atlanta, Ga.; azimuth at Cedar Keys, and triangulation from thence to Saint Marks along the Gulf coast; development by soundings of a shoal off Point Saint George; soundings in the Gulf approach to West Pass (Saint George's Sound, Fla.) and hydrographic survey of Saint Vincent Sound; height of the Atlanta base above sea-level determined, and triangulation (yet in progress) continued northeast and northwest of the base-line; reconnaissance for stations in the vicinity of Lookout Mountain, and for triangulation points near the course of the Ohio River; triangulation and hydrography of the Mississippi River between English Turn and Carrollton, La.; triangulation (yet in progress) for determining points in Missouri westward of Saint Louis; reconnaissance for points of triangulation in Wisconsin; measurement of base, triangulation, and shore-line survey of Sabine Pass, Tex.; hydrography of Pass Cavallo, including the bar, and of San Antonio Bay, Tex.; and tidal observations continued at Saint Thomas (West Indies).

On the Pacific coast of the United States, the operations of the present year include the development of a sunken rock off Point Loma near San Diego, Cal.; plane-table survey of the coast of Santa Barbara Channel from Newport Slough northward and westward to Bolsas River, including

part of the course of Santa Ana River; the topography of Santa Cruz Island; soundings between that island and Santa Rosa; survey of the coast of California between Point Conception and Point Arguello, also in the vicinity of Point Sal, and northward of Piedras Blancas, and near San Simeon; off-shore soundings between the Santa Barbara Islands and Monterey Bay; the addition of topographical details on the shores of Monterey Bay and Half Moon Bay; determination of the positions of light-houses between Santa Cruz and Point Reyes; hydrography and current-observations on the bar and inside of San Francisco Bay; discovery and development of a rock near the Middle Farallon; tidal observations at Fort Point near San Francisco; latitude, azimuth, and triangulation (yet in progress) to pass northward of San Francisco to Helena; and, as yet in progress—hydrography between Point Reyes and Cape Mendocino; coast-topography near Noyo River entrance; soundings south of Mendocino Bay and south of Trinidad; coast-topography between Rocky Point and Klamath River entrance; reconnaissance south of Point Saint George; in-shore and off-shore hydrography near Port Orford, coast of Oregon; survey of the shores and soundings in Umpquah River, and selection of site for a base-line near that entrance; topography of the coast south of Columbia River toward Tillamook; tidal observations in that vicinity; hydrography of the principal channels, and survey of the banks of Columbia River above previous limits; tidal observations continued at the permanent station at Astoria, and at Port Townshend, W. T.; hydrography of Budd's Inlet from Tumwater northward to Dana's Passage; survey of the shores and soundings in Duwamish Bay southward of West Point; hydrography of Puget Sound, W. T.; and development of facilities for navigation on the coast of Alaska Territory.

The office-work has been kept fully up to field-work of the preceding season. The computations of the current geodetic, trigonometrical, and tidal observations have made due progress, including the preparation of records and results for publication. Tide-tables for all ports of the United States for the year 1875 have been published. The drawing of thirty-five charts has been in progress, and that of seventeen has been completed. Ten new copper-plate charts have been commenced, forty-six have received additions, and eleven have been completed. Three new charts have been engraved on stone, and ten have been published by photolithography. An aggregate of 20,500 copies of charts has been issued during the year. The first volume of the Coast Pilot, or Sailing Directions for the Coast from Eastport to Boston, is passing through the press. Within the year, ninety-two manuscript charts have been traced on special call, either for the use of the Government, or for applicants who refunded the cost of copying.

The estimate for continuing the survey of the Atlantic and Gulf coasts of the United States is intended to provide for the following:

FIELD-WORK.—To continue the topography of the western shores and islands of Passamaquoddy Bay and its estuaries; of the coast and islands between Castine and Mount Desert, and of the shores of the Penobscot River between Castine and Bangor; to continue the determination of heights at some of the principal trignometrical points between Boston and the Saint Croix, and of co-efficients of refraction; to complete the hydrography of Penobscot Bay and River, and continue soundings to the eastward of Mount Desert; to make a hydrographic and topographical survey of Portsmouth Harbor; to make such additional triangulation as may be required for the topographical and hydrographic surveys, and determine the positions of new light-houses from Cape Cod to the eastward; to continue the resurvey of Monomoy and Nantucket Shoals, and the off-shore hydrography between Cape Cod and Manan, and make special examination for the sailing-lines for charts; to continue tidal observations, and to make such astronomical and magnetic observations as may be required; to continue such topographical and hydrographic surveys of the coast between Cape Cod and New York as may be found necessary; to make a survey of the Connecticut River from its mouth to Hartford; to make such examinations as may be required in New York Harbor, and such other surveys in its vicinity as may be required; to continue at that port observations on tides and currents; to extend the plane-table survey of Hudson River above Haverstraw; to make the requisite astronomical observations; to continue the triangulation between the Hudson River and Lake Champlain, the topographical and hydrographic surveys of the coast of New Jersey, and the resurvey of the hydrography of Delaware Bay and River; to connect the Atlantic triangulation with that of Chesapeake Bay near the boundary-line between Maryland and Virginia; to continue the detailed survey of the James River, Va., including the hydrography and the plane-

table survey of the Potomac River; to continue southward the main triangulation along the Blue Ridge, parallel with the coast, including astronomical and magnetic observations; to continue the supplementary hydrography between Delaware Bay, from Cape Henlopen to Cape Henry, and in Chesapeake Bay, also the tidal observations; the triangulation of Pamplico Sound, and the topography of its western shores between the Roanoke Marshes and Swan Quarter; to measure a base of verification and determine azimuth for the coast-triangulation south of Cape Lookout; to make the astronomical and magnetic observations requisite; to continue the off-shore hydrography between Cape Henry and Cape Fear, the hydrography of Pamplico Sound and its rivers, and that of Core and Bogue Sounds and of the entrance to Cape Fear River; to extend northward the primary triangulation along the Blue Ridge; to continue the topographical survey southward of Cape Romain; to determine azimuth for the triangulation of the coast of South Carolina and Georgia; to complete the detailed survey of the sea-islands and water-passages between Charleston and Savannah, and to make tidal observations; to make a hydrographic resurvey of Georgetown (S. C.) Harbor and approaches, and continue the off-shore hydrography between Cape Fear, N. C., and the Saint John's River, Fla.; to continue southward from Mosquito Inlet the triangulation, topography, and hydrography of the sea-water channels adjacent to the eastern coast of the Florida Peninsula; to make the requisite astronomical observations; to continue the off-shore hydrography of the Florida Peninsula, and complete soundings in the vicinity of the reefs and keys, continue soundings, observations for sea-temperatures in such parts of the Gulf Stream as may be deemed advisable between the west end of Cuba and Nova Scotia, and dredging along the coast, within the same limits, in conjunction with the United States Commissioner of Fisheries; to continue the astronomical and magnetic observations requisite between Cape Florida and Pensacola; to continue the triangulation, topography, and hydrography of the western coast of Florida south of Tampa Bay and in Charlotte Harbor, and of the coast of the peninsula between Cedar Keys and Appalachee Bay, and between Appalachee Bay and Saint Andrew's Bay; to run lines of soundings and make observations of sea-temperature in the Gulf of Mexico and develop the hydrography of the Gulf coast included in the field-operations; to connect the trigonometrical survey of the Mississippi River at New Orleans with that of Lake Borgne and Lake Pontchartrain; to determine geographical positions and make the astronomical and magnetic observations required; to extend the triangulation, topography, and hydrography westward of the Mississippi delta, and continue the hydrography of the Gulf of Mexico between the mouth of the Mississippi and Galveston, Tex.; to extend the triangulation, topography, and hydrography of the coast of Texas westward from Sabine Pass and south of Corpus Christi; to measure a base of verification, and make the astronomical and magnetic observations requisite, between Sabine Pass and the Rio Grande; to continue the hydrography of the approaches to the coast and of the bays and passes.

OFFICE-WORK.—To compute results from the field-observations made along the Atlantic and Gulf coasts, including astronomical, geodetic, geographical, magnetic, and tidal work; to continue the reproduction of the original topographical sheets and to plot hydrographic charts from records of the work; to continue the drawing of the general chart of the coast from Quoddy Head to Cape Cod, and of Charts Nos. 1 and 2, showing the coast of Maine between Saint Croix River and Petit Manan light-house; to continue the drawing and engraving of Charts Nos. 3 and 4, which include Frenchman's Bay, Blue Hill Bay, Isle au Haut Bay, Penobscot Bay, and their approaches, also local charts of Moose-a-bec Reach, the vicinity of Mount Desert Island, Eggemoggin Reach, Penobscot Bay east, Penobscot River, and of Monomoy Shoals; to begin the drawing and engraving of a chart of Portsmouth Harbor, N. H., the drawing and engraving of charts of the Thames River, Connecticut River, and Port Jefferson; to complete the drawing and engraving of a chart of New Haven Harbor, and commence a new edition of the chart of Long Island Sound; to continue the engraving of Chart No. 21, showing the coast between Sandy Hook and Barnegat Inlet, the drawing and engraving of Charts Nos. 22 and 23, between Barnegat and Cape May, and to make additions to the charts and sketches between New York and Cape Henry; to begin the drawing and engraving for a new edition of the chart of Delaware Bay and River, and to complete that of James River below City Point; to continue the drawing and engraving of general charts of the coast between Cape Henry and Cape Lookout, and of Charts Nos. 37, 39, 42, 43, 44, 45, 46, and 47, showing parts of the Atlantic coast between Cape Henry and Cape Lookout, including Pamplico

Sound; to commence engraving the general chart of the coast between Cape Hatteras and Cape Romain, and continue the drawing and engraving of that of the coast between Cape Romain and Saint Mary's River, and of Charts Nos. 51 and 52 between Cape Fear and Winyah Bay; to begin the drawing and engraving of a new chart of Georgetown Harbor, S. C., and make additions to the charts and sketches of coast between Cape Henry and the Saint Mary's River; to continue the drawing and engraving of the general chart of the coast from the Saint Mary's River to Cape Canaveral, and of Charts Nos. 58, 59, and 60, from Cumberland Sound to Cape Canaveral; to make additions to the charts of the coast between Saint Mary's River and Cape Florida, continue the drawing and engraving of Charts Nos. 79, 82, 83, 86, and 87, showing the Gulf coast between Chassahowitska River and Pensacola entrance, and of the chart of Tampa Bay; to begin the drawing and engraving of the chart of Saint Joseph's Bay, and continue work on the chart of Saint Andrew's Bay, and of Charts Nos. 91, 92, 93, 94, and 95, showing Lake Borgne, Lake Pontchartrain, Isle au Breton Sound, and the Mississippi River between New Orleans and the Gulf of Mexico; and of the general chart, showing the Gulf approaches to the Mississippi River; to begin the drawing and engraving of the chart of Barataria Bay, and of the general chart of the coast of Louisiana and Texas from the Atchafalaya to Galveston; to continue the drawing and engraving of that between Galveston and Rio Grande, and of Charts Nos. 109 and 110, showing Aransas Bay, Copano Bay, and Corpus Christi Bay.

For materials for drawing, engraving, map-printing, for electrotyping, photographing, for instruments, and apparatus.

Total for Atlantic and Gulf coasts, involving work on the shores of the following States, viz, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas, will require $415,000.

The estimate for continuing the survey of the Pacific coast of the United States is intended to provide for the following progress:

FIELD-WORK.—To make the requisite observations for latitude, longitude, azimuth, and the magnetic elements at stations along the Pacific coast of the United States; to continue off-shore soundings on the coast of California, Oregon, and Washington Territory, and tidal observations at San Francisco, Astoria, Port Townshend, and such other localities as may be necessary; to continue the primary triangulation from Monterey Bay to the southward, from Point Conception to the northward, or to the Santa Barbara Islands, and from San Pablo Bay to the northward; to continue reconnaissance for primary triangulation from San Buenaventura to San Diego, from Russian River to the northward, and from Columbia River north to Puget Sound and south up the Willamette Valley; to continue the coast triangulation and topography from Point Lasuen toward San Luis Rey and that of Santa Barbara Islands; to continue the detailed survey of the coast north and south of Point Conception; to continue the secondary triangulation and topography between Point Buchon and San Simeon; to continue the hydrography between San Diego and Point Conception, between Point Conception and Monterey Bay, develop the hydrographic changes in San Francisco Bay and its approaches, extend hydrography between Cape Mendocino and the Klamath River, between Cape Sebastian and Port Orford, north and south of, and in the approaches to, the Columbia River, and the hydrography of Puget Sound, Washington Sound, and adjacent waters; to observe currents along the coast and take soundings and temperature-observations in the California branch of the Kuro Siwo current, and execute such other hydrographic work as local demands may require; to continue tidal observations at the Golden Gate, and observations on the ocean-currents along the coast of California; to continue hydrographic work within the limits of field-operations; to continue the triangulation and topography between Bodega Bay and Point Arena, between Cape Sebastian and Port Orford, southward from Tillamook Head, and from Shoalwater Bay northward; to complete the detailed survey between Cape Sebastian and Crescent City, and off-shore hydrography at Crescent City Reef; to measure a base-line and continue the triangulation, topography, and hydrography of the Strait of Fuca, Puget Sound, and Washington Sound; to continue the reconnaissance of the coasts and islands of Alaska, with observations for tides and currents; to make the requisite astronomical and magnetic observations; and to con-

tinue hydrographic explorations in the vicinity of the Aleutian Islands, the Shumagin Islands, and the Kadiak group, with observations on tides and currents.

OFFICE-WORK.—To make the computations from the observations recorded in the field, including astronomical, geodetic, geographical, magnetic, and tidal observations; to continue the reproduction of the original topographical sheets, and to plot the hydrographic charts from the recorded work; to draw and engrave additions on the general chart of the Pacific coast of the United States; to continue the drawing and engraving of charts of the coast from San Diego to Point Conception; to engrave local charts of Catalina Harbor and Isthmus Cove, of San Pedro Harbor, of Anaheim and Hueneme Landings, and of San Luis Obispo; to complete the engraving of a new edition of the chart of San Francisco Entrance and Harbor; to continue the drawing and commence the engraving of charts of the coast from Point Arena to Cape Mendocino (No. 8), of that from Cape Mendocino to Saint George's Reef (No. 9), and of that from Saint George's Reef to the Umpquah River (No. 10); to complete the engraving of a chart of Humboldt Bay; and to make additions to the charts of Columbia River, Shoalwater Bay, Puget and Washington Sounds, and to the charts of the Northwestern coast, will require $290,000.

For extending the triangulation of the Coast Survey, to form a connection between the Atlantic and Pacific coasts of the United States, and assisting in the State surveys, involving work in ten States, $85,000.

For repairs and maintenance of the complement of vessels used in the Coast Survey, per act of August 18, 1856, $55,000.

For continuing the publication of observations made in the progress of the Coast Survey, including compensation of civilians engaged in the work, the publication to be made at the Government Printing-Office, per act of March 3, 1869, $10,000.

For general expenses of all the work, namely: Rent, fuel, for transportation of instruments, maps and charts, for miscellaneous office-expenses, and for the purchase of new instruments, books, maps, and charts, will require $38,100.

The annexed table shows, in parallel columns, the appropriation for the fiscal year 1874-'75, the amount estimated for that year, and the estimate herein submitted for the fiscal year 1875-'76.

Object.	Appropriated for fiscal year 1874-'75.	Estimated for fiscal year 1874-'75.	Estimated for fiscal year 1875-'76.
For continuing the survey of the Atlantic and Gulf coasts of the United States, including compensation of civilians engaged in the work and pay and rations of engineers for steamers used in the Coast Survey, per acts of March 3, 1843, and June 12, 1858	$375,000	$425,000	$415,000
For continuing the survey of the western coast of the United States, including compensation of civilians and pay and rations of engineers for steamers used in the work, per act of September 30, 1850	231,000	275,000	290,000
For extending the triangulation to join the survey of the Atlantic and Pacific coasts of the United States, and assisting in the State surveys, including compensation of civilians engaged in the work, per act of March 3, 1871	50,000	65,000	85,000
For repairs and maintenance of the complement of vessels used in the Coast Survey, per act of August 18, 1856	41,000	50,000	55,000
For continuing the publication of observations made in the progress of the Coast Survey, including compensation of civilians engaged in the work, the publication to be made at the Government Printing-Office, per act of March 3, 1869	9,000	10,000	10,000
For general expenses, as rent, fuel, purchase of instruments, and miscellaneous office-expenses	....	....	38,100
Total	706,000	825,000	893,100

DISCOVERIES AND DEVELOPMENTS.

Under this head were included, in former years, dangers to navigation discovered in the progress of the survey, and the determination in position and development of the character of such dangers as were already known to exist, but which could not be safely approached nor certainly avoided, because of the want of exactness in the means at hand previous to the commencement of the

survey for ascertaining their places relative to the shore-line. In strictness, the list of such items might include many other particulars, as no feature whatever along the coast has been found in close correspondence with the results of systematic development. No mention has been made even of errors much larger than might have been expected, as in general the errors on the State maps have been found within certain limits. In fact, they were at the outset the only guide in marking out the limits of sheets for the plane-table parties, and generally they have availed for that purpose. It has happened otherwise, however. Within the present season, a topographical sheet, intended to define the shores of an inlet of moderate size, though projected with due allowance for errors on the general map, was found insufficient in limits for the intended purpose. As regards fixed dangers in navigation, it needs not to be specially pointed out that the development by accurate survey of a bank near them may be a safeguard; the direction of the danger and its distance in some cases being known from the depth found by sounding on the bank, even in a dense fog.

Casual dangers in navigation, such as sunken wrecks, or spars projecting from them, are properly, and have not been less than permanent obstacles, subjects of attention in the operations of the hydrographic parties. If near a frequented channel, the larger parts of wreck, when broken and moved by the sea, are traced by soundings until the wreck is known to be in deep water; or, if not broken, the site of the danger is developed by soundings, the position is carefully determined, and notice of the danger is given in the usual printed form, as in the case of a newly-discovered rock or dangerous shoal.

In the operations of the present year, the following items have been specially mentioned in reports from the chiefs of hydrographic parties:

1. Rock found, with only seven feet of water on it, in the channel between Half Way Rocks and Star Island, Isles of Shoals, N. H.
2. A shoal spot on the south side of the Swash Channel, New York Bay, determined in position.
3. Rocks off Point Loma, coast of California, having two fathoms less water on them than had been previously reported.
4. Two sunken rocks developed in position and depth off Fort Point, San Francisco entrance.
5. Rock found half a mile southwest of the Middle Farallon.
6. Dangerous sunken rock found between Crescent City Harbor and False Klamath, Cal., abreast of the mouth of Wilson's Creek.
7. Shoal spot found in Chetko Cove, coast of Oregon.

COAST PILOT.

Though all known dangers to navigation are marked upon the charts, mariners have by long usage relied much on printed lists of obstacles near their sailing-courses; somewhat also on pictorial views; and as much on descriptions of proper sailing-lines and of the appearance of the coast and harbor-entrances. These last-named facilities, and especially compressed lists of dangers, are eagerly sought, because they give instant knowledge of the character of the waters to be traversed, and because they lessen the risk that any one danger, though marked on the chart, may be overlooked by the navigator.

The issue of a Coast Pilot, comprising printed notes based upon the actual systematic development of the coast by surveys, has been properly deferred until the connection of work done separately in many localities admits of continuous description.

Several years ago, one of the parties in service afloat was assigned to inspect the coast of New England, with local and general charts of the Coast Survey in hand; to test the charts, examine the dangers, prove the sailing-courses by trial, and to compile notes and descriptions. These were arranged by the party for publication, and have been issued in a volume which contains sailing-directions, etc., for the coast and harbors between Nova Scotia and Cape Cod, and generally for the body of water known as the Gulf of Maine. This party is now engaged in the same service on the coast between Boston and New York.

TIDES.

Tide-tables for the year 1874 were computed and printed in advance of the opening of the year, and were distributed at the principal ports on the Atlantic, Gulf, and Pacific coasts of the United States, so as to be available to all who have need for them. These tables show the time of high water and the height of tide for each day of the year. A similar ephemeris for the year 1875 has already been printed, and copies are now in the hands of agents, who are authorized to dispose of them at a cost to the purchaser so moderate as to bring the information within the reach of all inquirers. The same agents are authorized to sell the published charts of the Survey at the principal ports of the United States.

As an appendix to this report, a comprehensive paper by Mr. William Ferrel, of the Tidal Division, has been printed separately. In addition to modifications and improvement in the general theory of the tides, Mr. Ferrel's researches present various developments of the tidal forces, determinations of co-efficients and arguments in the different terms of the developments, and also equations of condition for ascertaining from observation for each tidal station the unknown constants in the corresponding tidal expressions. As the result of much practical work, improved methods are given for discussing tidal observations. These will be specially applicable to the several long series contained in the tidal records of the Coast Survey, and will in time avail further, as other series fill up, in the formation of tables and formulæ for predicting the tides at various stations along the coast of the United States with increased precision.

MAGNETISM.

In regard to the secular change of the magnetic declination, a discussion of much value has been added by Assistant Charles A. Schott, and is given in the Appendix (No. 8). The collection of observations of the deviation of the magnetic needle, which he has continued for some years, is given in the same paper in such form as to render the results convenient for furnishing compasses for our charts.

It will be seen by the paper here referred to that the empirical law of the secular change is marked with a considerable degree of reliability; its uniform operation being referable to any date in the list of recorded observations. The secular change is so expressed as to give the means for bringing up the observed declination at any time and place to what it would be at present, or at any other date within the range of recorded observations. The older observations, proved by the application of the law, thus in some cases avail, as well as recent determinations, for constructing charts to show lines of equal magnetic declination for any desired epoch. Besides the obvious use of the discussion for assigning the variation of the magnetic needle in the use of charts, the paper is otherwise of permanent value. The compilation of all the recorded observations at important places, from the earliest down to the present time, must always remain as the foundation for testing theories concerning the secular change of the magnetic declination, a subject which is yet imperfectly understood.

The usual annual determination of the magnetic elements was made by Assistant Schott in June, at the station on Capitol Hill, in Washington City. The object of this series of observations has been explained in previous annual reports, and it suffices here to say that the law of change heretofore recognized continues to hold good.

Another paper by Assistant Schott, in the Appendix (No. 9), results from elaborate discussion of the absolute measures of magnetic declination, dip, and intensity, and of the differential observations for declination recorded at Key West, between the years 1860 and 1866, with Brooke's self-registering instruments. The late Professor Bache, when Superintendent of the Coast Survey, had the apparatus set up there, remote from Toronto and Philadelphia, in order to secure a series of results that would show variations, due to geographical position, in the laws by which the motion of the magnetic needle is governed. Under uncertainty in regard to public affairs, Key West, on the Florida Reef, was selected in 1860 in preference to a station on the Western coast. The maintenance, moreover, of a station on the Pacific for the contemplated period of six years would have entailed at that time a disproportionate expenditure; but, as the Western series is desirable, arrangements for it will be kept in view.

Preliminaries for the observations at Key West were arranged by Prof. William P. Trowbridge, and the instruments when adjusted were left in charge of Mr. Samuel Walker, who was at that time on Coast Survey service.

The series of automatic observations is continuous from March, 1860, to March, 1866, for differential records of the declination, the horizontal intensity, and the total intensity, except in comparatively few cases, in which, from accidental causes, the photographic traces became illegible. The absolute determinations for declination, dip, and intensity were made at irregular intervals between February, 1860, and May, 1862, but subsequently were recorded regularly during four days in each month until the series closed.

The paper by Mr. Schott opens with a discussion of the record of absolute measures and presentation of the separate results, and the annual effect of the secular change, as also the annual variation. The readings of the photographic traces were tabulated for every hour, and those recognized as disturbances were first subjected to analysis by applying Peirce's criterion for excluding observations. The laws in regard to disturbances are fully brought out for easterly and for westerly deflecting forces, and their daily and annual variations are shown.

The solar diurnal variation of the magnetic needle at Key West is treated at length in the paper; the movement of the needle being shown from hour to hour, day and night, for each month, and also the epochs of greatest divergence, when the needle, after being stationary for a short time, reverses its motion. The hours when the daily average position of the needle is reached, with a total amount of daily divergence or amplitude, are also given in tabular form. Results for all the elements are illustrated by simple but effective diagrams.

The period of irregularity, which recurs at intervals of about eleven years, and which, as heretofore observed, seems to correspond with a period of recurrence in solar spots, is a subject of mention in the same appendix, as are also some comparisons of much interest between results found at Key West and those reached by means of observations which had been previously recorded at other stations.

For its possible bearing in the question that might hereafter arise in regard to disturbing effects on terrestrial magnetism from extraneous causes, Assistant Schott was requested to observe the variations of the magnetic needle closely during the period in which the tail of the Coggia Comet must have been *comparatively* near the earth. His observations were begun at the standard magnetic station in Washington City shortly after noon on the 20th of July, and were repeated at certain intervals until the morning on the 23d. The resulting curves graphically representing the solar diurnal variation of the needle on those particular days correspond very nearly with normal curves for the same month as determined in preceding years. It was hence concluded that at Washington, as no effect whatever on the magnetic equilibrium could be detected, no influence there could be imputed to the comet.

TRANSIT OF VENUS.

The act of Congress of June 10, 1872, specified that the sum then appropriated "for the purchase and preparation of instruments for a proper observation of the transit of Venus, which is predicted to occur on the eighth of December, eighteen hundred and seventy-four, should be expended under the direction of a commission, to be composed of the Superintendent and two of the professors of mathematics of the Navy attached to the Naval Observatory, the president of the National Academy of Sciences, and the Superintendent of the Coast Survey." Under this provision of law, Prof. Benjamin Peirce had taken an active part in the deliberations of the commission. When preparations had so far advanced as to admit of the organization of the observing-parties, it was decided that, of the eight parties to be sent out, two should be directed by officers of the Naval Observatory; two others under the charge of officers of the Coast Survey; two by astronomers from civil life; one by an officer of the Army; and one by an officer of the Navy.

The Coast Survey officers selected for this important duty are Assistant George Davidson, Sub-assistant O. H. Tittmann, and W. S. Edwards for the party of observation in Japan; and Sub-assistant Edwin Smith, aided by Mr. A. H. Scott, for the station on Chatham Island, in the South Pacific Ocean. Mr. T. P. Woodward, aid in the Coast Survey, was designated to accompany the party which has been assigned by the honorable Secretary of the Navy to observe the transit at a station in China under the charge of Prof. J. C. Watson.

When the duty of acting as a member of the Transit Commission devolved upon me, the general arrangements were already far advanced. Except in regard to some prospective details for the guidance of parties at their stations, it remained only to perfect the organization of the parties and expedite their departure.

In order to secure uniformity in practice, and to test the instruments which had been selected for use by the several parties, all the intended observers and their assistants were assembled at Washington in May. Messrs. Davidson and Tittmann came east from San Francisco and attended the personal conference of observers at the Naval Observatory.

Subassistant Smith sailed with his party from New York on the 10th of June, in the United States steamer Swatara, with several of the parties destined for stations other than Chatham Island. Professor Davidson with his party left San Francisco on the 29th of August, and, according to recent advices, is now settled at his intended station in Japan.

The observations made in 1769 by Chappe d'Auteroche in Lower California on the transit of Venus could not be made to yield their full value while a large uncertainty remained in regard to the position occupied by that observer at San José del Cabo. The veracity of his observations is proved by the satisfactory results derived from the use of his record of the observed "duration" of the transit; but the introduction of the absolute time of either the ingress or egress was not practicable in advance of a good determination of the longitude of the place occupied by the observer in 1769.

Assistant George Davidson, after searching all the printed narratives concerning the observations made in Lower California, visited San José del Cabo in the spring of 1873, and, by careful and thorough examination, identified the station at which Chappe had observed the transit of 1769. The results, including also determinations of the latitude and longitude of the place, are given in Appendix No. 10. It is hoped that the addition thus made to the record will enable astronomers to realize the full value of the observations made by Chappe.

Whatever other exact methods for determining the solar parallax may now be available, the results yielded by each of the observed transits of Venus must hold a prominent place, so long as the existence of so-called constant errors in any method remains uncertain, or so long as such errors reveal themselves only in the comparison of results by independent methods. Hence the question involved in the observations made at San José del Cabo is not one of merely historical interest.

LIGHT-HOUSE BOARD.

As far as possible, the purposes of the Light-House Board have been aided, as in former years, either by the voluntary action of members of the Survey in cases of emergency, or by their services under the direction of the Superintendent, in order to meet special calls for information. The frequent displacement of buoys; the means needful for identifying their places; determinations of the position of light-houses and of marks set as aids in navigation; tracings of the sites in question or selected for the construction of new light-houses, and other requirements bearing on the interests of commerce, keep up the intimacy of relation that necessarily exists between these two branches of the public service. This interchange, fostered for years by the association of the Superintendent of the Coast Survey as a member of the Light-House Board, became more direct when my predecessor, Prof. Benjamin Peirce, accepted the chairmanship of the committee on lighting. The duties thus devolved were discharged continuously until February of the present year, when, upon his resignation, Professor Peirce was replaced, in the board and as chairman of the committee on lighting, by myself. During the past year, my personal attention has been given to the details which of necessity come before that committee in advance of the expenditure of any means for alterations or for construction.

INSTRUMENTS.

Among various devices for detaching the heavy weight needful in deep-sea soundings, the method proposed by Lieutenant-Commander Sigsbee, and described in Appendix No. 14, invites attention by its simplicity. Provision has been made for the practical test of the plan in the Gulf of Mexico by the hydrographic party of Commander J. A. Howell, United States Navy, Assistant

in the Coast Survey, in the steamer Blake. Lieutenant-Commander Sigsbee will be associated in the same party, and personally supervise the operations in deep-sea hydrography, which include also the application of his improvement in apparatus for controlling the descent of the line or wire used in soundings.

In Appendix No. 13 will be found an exhibit favorable to wishes that have been long entertained in regard to economy in the use of coal for steaming at sea.

Of the various instruments for measuring angles, the sextant finds the most extensive use in the Coast Survey; each hydrographic party requiring at least two observers with the sextant now in use in order to secure simultaneous determinations of the two angles which are indispensable for determining the position of the sounding vessel. This necessity has induced search for an expedient by which the two angles can be taken by one observer.

The first step in this direction was made by Lieutenant (now Commander) P. C. Johnson, United States Navy, when in Coast Survey service in the steamer Active. He added a sliding stop, which could be clamped to the graduated arc in contact with the index-arm. By merely securing thus the position of the vernier for the first angle observed, the loss of time between the two observations occasioned by the reading of the first angle can be avoided, as the vernier can be set back, and the reading taken after the second observation has been completed. Two such stops, one on each side of the vernier, render it indifferent whether the greater or less angle is measured first, and relieve the observer from the necessity of deciding that question. The time, however, that still necessarily elapses between the two observations, during which the boat changes its place, renders the method insufficient for very accurate work.

Within the year, Mr. T. J. Lowry, aid in the Coast Survey, has suggested several improvements, by means of which sextant-angles between 140° and 180° can be observed, and two angles can be taken by one observer at the same instant or in quick succession. The first object is accomplished by making the back as well as the front face of the index-glass reflecting, by adding 120° to the reading of the arc whenever the back face of the index-glass is the reflecting surface, and by placing a second horizon-glass on the line of sight at such an angle as to reflect the rays from the back of the index-glass parallel to the line of sight.

To make the sextant capable of measuring two angles, one to the right and the other to the left of the central object, in quick succession, Mr. Lowry proposes to make the arc of the instrument 120° instead of 60°, as in the ordinary sextant; the graduation to be numbered in opposite directions from 0° to 120°, it being actually 60° from each zero. Each arc carries its own index-arm and index-glass, having the horizon-glass in common. The index-arms may have the same or different centers of motion. In the first case, the glasses may be mounted, either one above the other or at the same level, by making each only half the ordinary width, their inner edges joining.

Another form of sextant has been suggested by Mr. Lowry, by which two angles, one to the right and the other to the left of an object, can be quickly measured. By placing an additional index-glass over the ordinary one at an angle of 60°, angles to the right of the line of sight can be measured, zero reading 120° on the graduation of the common sextant. The first angle observed may be secured by a detachable stop, similar to that first proposed by Lieutenant Johnson.

The design for a reflecting-instrument, submitted by Charles Junken, assistant in the Coast Survey, provides for measuring two angles at the same time. This instrument is equivalent to two sextants, mounted upon the same plane, with the telescope in common. The horizon-glasses are placed one above the other; the index-glasses, index-arms, and graduated arcs are attached symmetrically to each side of the line of sight. In either of the devices for the simultaneous measurement of two angles, one index-arm is put at such an angle that the image of one of the reflected objects will fall near the central object, and be carried toward it by the motion of the ship. By means of the tangent-screw attached to the other index-arm, the image of the third object is kept in contact with the central object until the first image becomes coincident with the central object.

Improvements of the kind here mentioned can have practical value only after they have been fully tested by experience. The expense being small, the construction of a model has been authorized, to combine the main features of the proposed improvements.

OBITUARY.

John Farley, esq., who had completed thirty-seven years of service as assistant in the Coast Survey, died at Narragansett Pier, Rhode Island, on the morning of July 31, in the seventy-first year of his age, and, at the approach of his last day, was faithfully engaged in field-duty.

Mr. Farley was a native of Charlestown, Mass. He graduated at West Point in 1823, and was successively assigned second lieutenant of the First United States Artillery, assistant professor at the United States Military Academy, and in the War Department for topographical duty until 1826; in the engineer survey of a canal-route from Chesapeake Bay to Lake Erie until 1827; to artillery service at Fortress Monroe, but, under special direction from the War Department, he inspected in Europe systems then current in representative art for military maps and drawings; after his return, to the command of Bellona Arsenal, Richmond, Va.; then to the Topographical Engineer Office, United States Army, Washington, D. C., in charge of lithographic engraving for adapting the best methods observed in Europe; in December, 1832, to the command of Castle Pinckney, Charleston Harbor, S. C., with Company C, First United States Artillery; in 1834, with his company, to Fortress Monroe; thence to Fort King, Fla., where, after remaining one year, and being then senior first lieutenant in the First Regiment of Artillery, he resigned in 1835, on account of failing health, after twelve years of service in the Army.

Mr. Hassler, while organizing work as Superintendent of the Coast Survey, and seeking qualified officers, tendered to Mr. Farley the position of assistant in the Coast Survey. This offer was accepted in 1837, and at his decease he was the oldest assistant in the branches of work to which his talents were subsequently devoted.

In all the climates of our extended coast, at all seasons, through his advancing years, and without remitting for private affairs, Mr. Farley was ever ready cheerfully and ably to perform any field-duty committed to his charge; and the archives of the Survey have been specially enriched by his industry and his skill. His words, uttered in usual health, and when about to start for the field in July—"I have lived the allotted time of life; every day is now from God's bounty; I am ready, and await my General's call"—are realized in the sad event. We recognize in their import his fortitude and his exalted sense of duty. In the relations now severed by death, the memory of Mr. Farley will remain with us, a heritage of valued associations, due to his sterling qualities, cordiality and refinement of feeling, manly dignity, and unvarying kindness in the intercourse of life.

PART II.

The abstracts which follow will be arranged in geographical order, as heretofore, beginning with the northeastern boundary of the United States, and proceeding from point to point southward to the Rio Grande on the Gulf coast. For the Pacific coast, the localities in which work has been done within the year will be named in the reverse order, beginning with San Diego, and terminating with the mention of operations on the coast of Alaska.

By the attention of Assistant Richard D. Cutts, in regard to the details of secondary triangulation, due provision has been made for all requirements in that branch of the service, on which, in fact, depends the steady advance of the topographical and hydrographic parties. When the season opened, and means became available for work at the North, Assistant Cutts took the field for the selection of stations by which connection may be made between the primary triangulation of the coast of New England and that of the Hudson River; and also to connect the latter with the triangulation of Lake Champlain.

In the course of the season, Assistant Whiting personally conducted the survey of Providence Harbor, as will be described under the head of Section I, visited the parties at work near Norfolk, and conferred personally in regard to the details then in progress; and also in reference to the means and outfit proper for other topographical surveys, that will be mentioned under the head of Section III. The plane-table work advancing on the shores of Pamplico Sound was inspected, and the operations of the topographical party at work during the spring on the coast of South Carolina. At Savannah, Mr. Whiting carefully examined the survey there in progress, and also the opera-

tions of the several parties that were prosecuting work near Mosquito Inlet and on the shores of Tampa Bay.

In regard to hydrographic details, including the care and outfit of vessels, to which I have, as usual, given immediate attention, it is gratifying to record that official relations, maintained as heretofore with the Navy Department, have greatly advanced the interests of the service.

Assistant Henry Mitchell passed the winter in discussing observations which had been conducted and recorded, under his immediate direction, in the physical survey of New York Harbor. The results gave data of immediate value to General Humphreys, Chief of Engineers, General Newton, and myself, and much availed in our decision as the commission for establishing bulkhead and outer pier lines on the Long Island side of New York Harbor. While the office-work connected with the physical survey was yet in progress, in February, at the joint request of the honorable Secretary of the Navy and of the commission on the construction of an interoceanic ship-canal, Mr. Mitchell was assigned, as an officer of the Coast Survey, to make, in conjunction with officers of the United States Engineers and others, a personal inspection of routes indicated by the several surveys which have been prosecuted in Central America under the direction of the Navy Department. The associated officers met together at Pensacola late in February, and, sailing immediately for Greytown, addressed themselves to the discharge of the assigned duties.

Following his own previous line of research, Mr. Mitchell noted, at the sea-outlets of the several proposed ship-canal routes, the changes likely to result from structures needful in establishing harbors for the shipping that must pass through from ocean to ocean. As far as practicable in the few weeks allowed for observing, the several localities were compared with other places, which, under similar conditions, are already much better known from continuous observations. The results of his inspection were embodied, at his return in June, in notes and remarks, which I have placed for future reference in the Appendix (No. 12) of this report, as foresight and general interest in the subject must hold until the great design is accomplished.

In July, Assistant Mitchell resumed operations in the physical survey of New York Harbor, and, in the course of the season, will conduct also a special hydrographic survey in Providence Harbor, R. I. These will be noticed in detail in my next annual report, in which the time covered by the surveys reported will conform with the fiscal year, ending with the month of June. Under appointment from the President of the United States, as a member of the commission to examine plans for improving the outlet of the Mississippi River, Mr. Mitchell will engage personally in that service during the coming winter.

SECTION I.

ATLANTIC COAST OF MAINE, NEW HAMPSHIRE, MASSACHUSETTS, AND RHODE ISLAND, INCLUDING SEAPORTS, BAYS, AND RIVERS.—(SKETCHES NOS. 2 AND 3.)

In making this report conformable with the limits of the fiscal year, the details of work done after the 1st of July will not be included. Mention, however, will here be made of the parties now in the field; and, in Appendix No. 1, the localities in which they are at work are given, as usual, in geographical order, each of the operations being marked as in progress. The recapitulation is as follows:

1. Deep-sea soundings between Nova Scotia and Cape Cod, developing depths in the coast-approaches through the Gulf of Maine, by the party of Commander J. A. Howell, U. S. N., assistant in the Coast Survey; Lieutenants W. H. Jacques, J. W. Hagenman, E. S. Jacob, and Richard Rush, and Master C. A. Bradbury, U. S. N., assistants.

2. Topographical survey of the western and north side of Mount Desert Island, Me., and soundings in the vicinity, by the party of Assistant J. W. Donn, aided by Messrs. F. C. Donn and F. H. Parsons.

3. Detailed survey of the shores of Eggemoggin Reach, coast of Maine, by the party of Assistant W. H. Dennis, aided by Mr. S. N. Ogden.

4. Topography of islands and ledges east and west of Isle au Haut and Deer Isle, Penobscot Entrance, by the party of Subassistant J. N. McClintock, aided by Messrs. W. Fraser and T. A. Harrison.

5. Plane-table survey of the eastern shore of Penobscot River, between Castine and Bucksport, by three parties in charge of Assistant A. W. Longfellow, Assistant Hull Adams, and Subassistant J. Hergesheimer, aided by Messrs. W. C. Hodgkins and R. B. Palfrey.

6. Hydrography at the head of Penobscot Bay, including the lower part of Penobscot River, Me., by the party of Assistant Horace Anderson, assisted by Master Kossuth Niles, U. S. N., and aided by Mr. F. H. North.

7. Determination of the co-efficient of refraction and of vertical height at the primary station, Ragged Mountain, near Camden, Me., by the party of Subassistant F. W. Perkins, aided by Messrs. C. L. Gardner and F. W. Ring.

8. Tidal observations at North Haven, Penobscot Bay, by Mr. J. G. Spaulding.

9. Soundings in the vicinity of Jeffrey's Ledge, Cashe's Ledge, and Jeffrey's Bank, surface and deep-sea temperatures recorded, and hydrography of the vicinity of the Isles of Shoals, by the party of Acting Master Robert Platt, U. S. N., assistant in the Coast Survey, aided by Mr. J. B. Adamson.

10. Determination of geographical positions by triangulation in New Hampshire, under the charge of Prof. E. T. Quimby.

11. Tidal observations at Boston by H. Howland.

12. Pendulum observations at a station near North Adams, Mass., and topographical survey to determine differences in the intensity of gravitation, by the party of Assistant C. S. Peirce, aided by Mr. W. E. McClintock.

13. Hydrography continued to develop the character of changes in depth at the eastern approach to Nantucket Sound, by the party of Subassistant F. D. Granger, assisted by Lieut. R. D. Hitchcock, U. S. N., and aided by Mr. D. C. Hanson.

14. Special examination and tests of sailing-courses between Narragansett Bay and New York, and supplementary hydrography in Long Island Sound, by the party of Assistant J. S. Bradford, aided by Mr. John Barker.

15. Detailed survey of the shores and hydrography of Taunton River, Mass., by the party of Assistant A. M. Harrison, aided by Messrs. W. H. Stearns and Bion Bradbury.

16. Special shore-line development and observations on tides and currents to determine the effect of proposed changes in the contour of Providence Harbor, R. I., by Assistants H. L. Whiting and Henry Mitchell, with a party in charge of Assistant H. L. Marindin.

Tidal observations.—The series of tidal and meteorological observations begun in January, 1870, at North Haven, in the entrance to Penobscot Bay, Me., has been carefully continued throughout the present year by Mr. J. G. Spaulding. His success in preserving unbroken the register of high and low waters, and the regularity and good form of the curves traced by the self-registering gauge, indicate that the position is favorable for the observations. This station is furnished with duplicate interchangeable cylinders, reading-box, and conveniences for regularly tabulating the readings of high and low waters, and hourly ordinates from curves as they are traced by the self-registering apparatus.

At the Boston navy-yard, the observer, Mr. H. Howland, has continued as heretofore the series of tidal and meteorological observations. The gauge in use at this important station is one of the best of the old form, and, as far as possible, is guarded against stoppage by attached heating-apparatus for use during winter. In general, the series has been well preserved.

A tide-gauge of the new form remains at Providence, R. I., where it was placed at the request of the city authorities. Last summer, the instrument was refurnished for continuing observations needed in the adjustment of levels in the local surveys; the running expenses, as heretofore, being met by the city. The apparatus and records will be returned to the Coast Survey Office, and will be of special use for comparison with the several short series of tidal observations recorded by sounding-parties while the hydrography of Narragansett Bay was in progress.

SECTION II.

ATLANTIC COAST AND SEAPORTS OF CONNECTICUT, NEW YORK, NEW JERSEY, PENNSYLVANIA, AND DELAWARE, INCLUDING BAYS AND RIVERS.—(SKETCHES NOS. 4 AND 5.)

At the outset of the present fiscal year, parties were assigned to duty in this section, and are now engaged, as follows:

1. Plane-table survey of the shores and soundings in Thames River, Conn., above the navy-station at New London, by the party of Assistant H. G. Ogden, aided by Mr. D. B. Wainwright.
2. Topography of the shores of New Haven Harbor, Conn., by the party of Assistant R. M. Bache.
3. Positions of light-houses to be determined, at the eastern entrance of Long Island Sound, by Assistant J. A. Sullivan.
4. Hydrography of the channel westward of Plum Island, Long Island Sound, by the party of Assistant J. S. Bradford.
5. Special observations on tides and currents in the waters of New York Harbor, and soundings in the lower bay, by the parties of Assistant H. Mitchell, Assistant F. F. Nes, and Assistant H. L. Marindin, assisted by Master H. O. Handy, U. S. N., and aided by Mr. W. B. French.
6. Survey of the shores and hydrography of Port Jefferson, Long Island Sound, by the party of Assistant F. H. Gerdes, aided by Subassistant C. P. Dillaway and C. A. Ives.
7. Tidal observations in New York Harbor, by R. T. Bassett.
8. Selection of stations for triangulation to connect the survey of Hudson River with the survey of Lake Champlain, by the party of Assistant R. D. Cutts, aided by Mr. J. F. Pratt.
9. Shore-line survey of Lake Champlain from Whitehall north to the Four Brothers, and topography of Crown Point and Ticonderoga, by the parties of Assistant C. T. Iardella and Subassistant Andrew Braid, aided by Messrs. H. W. Bache, subassistant, and C. H. Sinclair.
10. Hydrography of Lake Champlain from Whitehall northward to Shelburne Bay, and development of shoals in the vicinity of Isle Lamotte, by the party of Assistant Charles Junken, aided by Messrs. E. H. Wyvill and G. A. Morrison.
11. Latitude and azimuth determinations at Hudson, Crown Point, and Rouse's Point, N. Y., by the party of Assistant G. W. Dean, aided by Mr. A. G. Pendleton.
12. Shore-line survey and soundings in Great South Bay, Long Island, N. Y., by the party of Assistant Charles Hosmer, aided by Mr. John De Wolf.
13. Determinations of the magnetic declination, dip, and horizontal intensity at Ithaca and Oxford, N. Y., at Bethlehem, Penn., and at Cape May, N. J., by Mr. T. C. Hilgard.
14. Topography of the shores of Barnegat Bay, N. J., by the party of Assistant C. M. Bache, aided by Messrs. H. M. De Wees, subassistant, and J. J. Evans.
15. Soundings in the lower part of Barnegat Bay, N. J., and hydrography of the bar at Little Egg Harbor, by the party of Subassistant W. I. Vinal, aided by Mr E. B. Pleasants.
16. Latitude and azimuth observations at Keyport and Barnegat, N. J., positions of light-houses at Cape May, and also in Delaware Bay at Maurice River, Mispillion Creek, and Hereford Inlet, by the party of Assistant Edward Goodfellow, aided by Mr. C. A. Ives.

While sounding in the vicinity of the Swash Channel, New York Bay, Assistant Nes found a shoal spot with less water than had been previously known. In order to determine the question whether or not similar lumps existed in the channel, a careful development was made by close soundings within an area of about four square miles, including the course through the Swash. These confirm in general the results of previous surveys, and, in addition, reveal the existence of a small spot, with only 16½ feet of water, on the west side of the Swash Channel.

In the field-operations of last year were included observations which served for determining the exact geographical position and length of the boundary-line between the States of New Jersey and New York. Due acknowledgment for that service has been made by the authorities of the first-named State, at whose instance the work was performed.

As one of the results of the subsequent labors of the State officer in tracing out the boundary-

line, it was found that several actual residents of Bergen County, N. J., had for years paid their taxes and had voted as citizens of the State of New York.

Tidal observations.—The self-registering tide-gauge at Governor's Island (New York Harbor) has recorded the tides of the year, as heretofore, under the charge of Mr. R. T. Bassett. For comparison, the tides have been also recorded occasionally at Hamilton Avenue Ferry, Brooklyn.

Arrangements are now well advanced for beginning a series of tidal observations at a station on Sandy Hook, and a series also at Throg's Neck. The precautions requisite for maintaining the records unbroken have caused delay in the establishment of a gauge in a position so much exposed as the station must be at Sandy Hook.

SECTION III.

ATLANTIC COAST AND BAYS OF MARYLAND AND VIRGINIA, INCLUDING SEAPORTS AND RIVERS.—(SKETCH No. 6.)

Coast Pilot, Chesapeake Bay.—The work of compiling for publication a directory for the Atlantic coast has been continued by Assistant J. S. Bradford, with a party in the schooner Palinurus. In December, 1873, the special examinations were resumed in Chesapeake Bay. For all the harbors which had not been previously visited, sailing-lines were tested, and descriptions of the entrances were added to the material already on hand, for an additional volume of the Coast Pilot. This service in the Chesapeake was completed in January, after which the party passed southward of Cape Henry for duty, which will be the subject of notice under the head of Section IV. During the summer, Assistant Bradford was engaged in Section II.

Topography near Washington, D. C.—In April last, at the request of Captain Jeffers, Chief of the Bureau of Ordnance, United States Navy, a minute survey was made of the site of the naval magazine at Marbury Point on the Potomac River. Subassistant Joseph Hergesheimer, who was detailed for this service, carefully developed the ground surface by lines of level, and mapped the topographical features on a scale ample for any purpose desired in drainage or construction. By curves of equal elevation for every foot difference of level above high-water line, the sheet shows minutely the irregularities of surface.

On two plane-table sheets of previous seasons, Mr. Hergesheimer traced the recently-constructed line of the Baltimore and Ohio Railroad within the District of Columbia, and mapped the topography between the road and the Potomac shore-line. Among the details shown by this survey are the Washington approach of the Baltimore and Potomac Railroad east of the tunnel, and surface-features in the vicinity, which will appear in the next issue of the engraved chart of the Potomac River.

Subassistant Hergesheimer, during the summer, conducted a plane-table party in Section I.

Triangulation of the Potomac River, Va.—The local triangulation made of the Upper Potomac, by Assistant J. A. Sullivan in 1864 has been connected with the primary work at Sugar Loaf Mountain, on which the station first occupied was found to be nearly coincident with the point subsequently determined in the progress of the general geodetic operations. Early in July, Mr. Sullivan went to his station of 1864, and carefully determined its position relative to two primary points, which were occupied a few years ago by Assistant Boutelle, one on that mountain and the other on Maryland Heights. After measuring the horizontal angle, Assistant Sullivan ascertained the exact distance (a little over twenty-five feet) between his station of 1864 and the primary triangulation point on Sugar Loaf Mountain. His subsequent service in the field has been mentioned under Section II.

Triangulation in progress.—The party of Assistant A. T. Mosman, aided by Mr. D. S. Wolcott, is now in the field, and will extend the primary triangulation southward along the Blue Ridge in Virginia.

Assistant S. C. McCorkle, at the opening of the fiscal year, took the field in the vicinity of Staunton, Va., to conduct a reconnaissance westward, and, if practicable, select intervisible stations for a chain of triangles through West Virginia to the Ohio River.

Magnetic observations.—During three days in the middle of June, Assistant Charles A. Schott repeated observations for the magnetic declination, dip, and horizontal intensity at the station on Capitol Hill, Washington, D. C. These are in continuation of a series which now extends through eight consecutive years. The results found in June last show a close accord with values computed by the formulæ given by Mr. Schott in 1870, as will be seen by reference to Appendix No. 14 in the report for that year.

Triangulation, topography, and hydrography of James River, Va.—At the lower end of Jamestown Island, to which point the final survey had been advanced in the previous season, Assistant J. W. Donn resumed operations early in December, with a party in the schooner Scoresby. Field-work was prosecuted at all favorable intervals until the end of April, at which time the detailed survey of the James River was closed for the season at Sandy Point. The operations in this quarter will include also the survey of thirty-five miles of the course of the Chickahominy. As a basis for that work, Mr. Donn extended a separate triangulation from the mouth of the river upwards to the point known as Shipyard. The topographical details of the shores were afterward mapped and made conformable to the margin of topography, which will appear on the final chart of the James River.

The month of April was occupied by the party in the Scoresby in sounding within the limits of field-work. A synopsis of statistics is appended:

Miles of river shore-line traced	56
Miles of creeks	89
Miles of roads	48
Area of topography (square miles)	56
Miles run in sounding	392
Angles measured	2,094
Number of soundings	19,145

Assistant Donn was aided in this section, and subsequently in Section I, by Messrs. F. C. Donn and F. H. Parsons. The party in the Scoresby will be engaged during the coming winter in the survey of the James River in the vicinity of City Point.

Topography of Norfolk, Portsmouth, and Gosport, Va.—The detailed survey of the vicinity of Norfolk was taken up by Assistant C. M. Bache on the 7th of January, and was completed on the 4th of April. Field-work in this quarter was much retarded by unfavorable weather. As usual, the time unfit for pushing the survey was occupied in inking the plane-table sheets pertaining to field-work of the preceding summer and autumn in Section II.

The detailed survey of the cities of Norfolk, Portsmouth, and Gosport, on a scale large enough to meet any supposable requirements, was made without reference to the existing maps, which, however, were tested by Assistant Bache in advance of passing over the same ground. The statistics of his survey are:

Miles of shore and wharf lines	34½
Miles of roads and streets	87½
Area of topography (square miles)	10½

Subassistant H. M. De Wees was attached to the topographical party, and Mr. W. W. Gilbert served in it temporarily as aid, in the work near Norfolk, and also for the service mentioned under the next head.

Shore-line survey of Nansemond River, Va.—For this service, the schooner Dana was assigned to the charge of Assistant Bache, and work was commenced on the 8th of April. Newport News was occupied as a station for determining the points at the entrance of the Nansemond, and, in connection with them, others were determined by means of the plane-table for the shore-line survey, which was ultimately extended southward as far as Suffolk. At intervals of about five miles along the course of the river, three short bases were measured, with results proving the accuracy of the plane-table triangulation. In the aggregate, fifty-two miles of shore-line were traced by Assistant Bache and Subassistant De Wees. The plane-table sheet represents eighteen miles of the course of the Nansemond. While this work was in progress, Mr. Bache inked and sent to the

office his maps of the vicinity of Norfolk. The schooner Dana was returned at Norfolk on the 4th of June, after which preparation was made for resuming topographical work on the coast of New Jersey, as already mentioned under the head of Section II.

Hydrography of Nansemond River, Va.—As the shore-line survey advanced along the course of the Nansemond, tracings were furnished to the hydrographic party of Acting Master Robert Platt. In the absence of the chief, the aid, Mr. J. B. Adamson, prosecuted soundings without delay, and, on the 10th of June, closed the hydrographic survey of the Nansemond at Suffolk. On the chart, which was plotted at once and sent to the office, is the following synopsis of statistics:

Miles run in sounding	296
Angles measured	2,122
Number of soundings	18,172

Two months were occupied in this work. On its completion, Acting Master Platt proceeded to Norfolk, and, after outfitting the steamer Bache, took up service with his party in that vessel, as was stated under the head of Section I.

Supplementary hydrography.—In order to complete the chart of Elizabeth River, Va., a party will be sent in charge of Mr. J. B. Baylor to sound the passage back of Craney Island. As in other cases in which work is begun after the close of the fiscal year, which ended with June, further mention of the work executed will be reserved for my next annual report.

Tidal observations.—A self-registering tide-gauge of the new form, with interchangeable cylinders, reading-box, and also facilities for tabulating the record, has been substituted for the apparatus formerly in use at Old Point Comfort, Va. Mr. W. J. Bodell remains in charge as observer, and has well maintained the continuity of the record, notwithstanding the instability of the place at which the apparatus was of necessity fixed. For the pendulum, a balance-wheel has been substituted in the clock of the gauge. As a result, the clock has not been easily stopped, as it was in former years, and the tidal record is correspondingly improved.

SECTION IV.

ATLANTIC COAST AND SOUNDS OF NORTH CAROLINA, INCLUDING SEAPORTS AND RIVERS.—(SKETCH No. 7.)

Coast Pilot.—Assistant J. S. Bradford, with his party in the schooner Palinurus, sailed from Cape Henry on the 18th of February, bound for Charleston, with a view of noting such particulars in navigation as might be recommended to coasters. During the run, heavy weather prevailed, with mist and rain. The expedients thereby necessitated for the management of his vessel proved worthy of record as to the proper course to be run by coasters in thick weather to clear the Lookout and Frying Pan Shoals. Soundings were taken as the vessel approached these dangerous banks, and observations were recorded as to the set and drift of the current in crossing Long Bay and Onslow Bay. In the next section, mention will be made of the further operations of the party in the Palinurus.

Triangulation and hydrography of Chowan River, N. C.—The worn-out steamer Hetzel, which had been used as a hulk for several seasons by parties working in this section, as mentioned in previous reports, sunk at her anchorage in Edenton Bay last autumn; but no other vessel being available, at the opening of winter, for service in this quarter, direction was given for raising the vessel. By the middle of December, 1873, Assistant R. E. Halter, having put the hulk in condition to serve as quarters for his party, proceeded up Chowan River, and made a triangulation from its mouth inland to a point twenty-eight miles from the head of Albemarle Sound, determining positions for use in the hydrography. The waters of the Chowan, within the same limits, were subsequently sounded by the party. Messrs. C. L. Gardner and C. H. Fitch served as aids.

The following are statistics of this survey:

Signals erected	22
Stations occupied	20
Angles measured	638

Number of observations	8,014
Miles run in sounding	406
Sextant-angles	2,663
Number of soundings	30,675

The tides were recorded at six stations while soundings were in progress. Operations were closed in the middle of May. In the following month Mr. Halter started on duty of which mention will be made under the head of Section VII.

Topography of Chowan River, N. C.—The detailed survey of the banks of this river was commenced late in January by a party working under the direction of Assistant Hull Adams. Mr. R. B. Palfrey served as aid. Operations with the plane-table advanced as points were furnished by the triangulation. On the west side of the river, the parallel road passing south from Coleraine was taken in as the limit of the marginal topography, and surface-features elsewhere were mapped to the same average distance from the shore-line. The vicinity of Edenton is included on the plane-table sheet, and all improvements on both sides of the river to points as high up as Harrel's Wharf, or about thirty miles from the entrance of the Chowan. The topographical sheet represents five steamboat-landings, at which the large amount of cotton brought from the back counties is shipped for Norfolk and Baltimore. Much local interest was manifested while this survey was in progress. Field-work was closed by Assistant Adams in this section at the end of May. On the plane-table sheet of the Chowan, the recorded statistics are:

Miles of shore-line traced	92
Miles of roads	94
Area of topography (square miles)	43½

In June, this party was transferred to the coast of Maine, for service which has been mentioned under the head of Section I.

Triangulation of Pamplico Sound, N. C.—The party of Assistant G. A. Fairfield has been continuously employed in this work without transfer, as in other cases on account of change in the season. When the last annual report was closed, the party occupied Egg Shoal, a station in the vicinity of Hatteras Inlet. Horizontal angles were measured during the winter; and, early in January, Assistant Fairfield moved to Long Shoal Point. At all the stations, high platforms have been erected of necessity, to bring into view the signals on the opposite shore of the sound. The work is now advancing to the immediate vicinity of the Bodie's Island base, at the north end of which a platform eighty-two feet high was needful in order to bring into view the signal at Roanoke Marshes. The statistics of the work since the date of the field-report of last year are:

Signals erected (3 primary and 12 secondary)	15
Stations occupied (3 primary and 10 secondary)	13
Angles measured	90
Number of observations	7,280

Assistant Fairfield is aided in the triangulation by Messrs. B. A. Colonna and W. B. Fairfield. The party uses the steamer Hitchcock for transportation and quarters. It is confidently expected that the triangulation of Pamplico Sound will be finally connected with the primary base-line in the course of the ensuing spring.

Topography of Pamplico Sound, N. C.—The work of Assistant C. T. Iardella in this section defines the north shore of Pamplico Sound eastward of the entrance to Pamplico River; and, extending in that direction, it includes Swan Quarter Island and indentations known as Bell's Bay, Rose Bay, Swan Quarter Bay, Juniper Bay, and others. The plane-table sheet represents the roads and other surface-features adjacent to the shore-line.

The bays embraced in this survey afford safe anchorage for vessels drawing seven or eight feet water. In reference to the character of the shores, the field-report states that "the section of country from Pungo River to Swan Quarter is very thickly settled, and each of the fine farms along the main road is traversed by ditches, through which the farmers transport their grain and provender in small boats, to load vessels that remain at anchor in the several bays".

Subassistant H. W. Bache was attached to this plane-table party, and accompanied Assistant Iardella for field-service, which has been mentioned under the head of Section II. The statistics of the work on Pamplico Sound, in which the party was occupied during the first three months of the present year, are:

Miles of shore-line surveyed	170
Miles of roads	49
Miles of streams, etc	19
Area of topography (square miles)	86

Hydrography of Pamplico Sound, N. C.—This work has been well advanced by Assistant F. F. Nes with a party in the steamer Arago. The additional soundings, resumed on the 1st of January and continued until the 22d of May, extend the hydrography along the north shore of Pamplico Sound from Bell's Bay eastward to the vicinity of Gull Shoal Rock and southward to limits reached in the operations of previous seasons. The upper part of Pungo River was also sounded by the party. In the course of the season in this section, tides were recorded for limited periods at six stations, sixty shore-stations were occupied, and seventy-four signals were set up. All the buoys and channel-stakes within working-limits were carefully determined in position, and are marked on the hydrographic sheets. The general statistics are:

Miles run in sounding	1,132
Angles measured	7,304
Number of soundings	88,997

Messrs. E. B. Pleasants and W. B. French were attached as aids to the hydrographic party. Work prosecuted by Assistant Nes during the summer has been stated under the head of Section II.

Hydrography of Beaufort Harbor, N. C.—Subassistant W. I. Vinal, with his party, in the schooner Bowditch, left Norfolk on the 9th of January, and, taking the inside passage, engaged a fortnight afterward in soundings on Beaufort Bar. The hydrography of the approaches was pushed at all favorable intervals; and subsequently soundings were made inside developing the harbor, as it is at present, and also North River and Newport River, the limit of work in the latter taking in also the canal which joins that branch of Beaufort Harbor with the waters of Neuse River. This service occupied the party until the 18th of May, when Mr. Vinal took up hydrographic work at Cape Fear, as will be mentioned in detail hereafter.

For determining points needed in the hydrographic survey of Beaufort Harbor, thirty-two signals were erected, and forty-three stations were occupied with the theodolite. All the buoys were determined in position and marked on the hydrographic sheets. The statistics of survey are:

Miles run in sounding	387
Angles measured	2,937
Number of soundings	61,172

Messrs. J. J. Evans and W. S. Bond served as aids in this party. A comparison of hydrographic sheets shows that no special changes have occurred within the last ten years in Beaufort Harbor. Buoys on the bar were reset in June after the departure of the party in the schooner Bowditch.

SECTION V.

ATLANTIC COAST AND SEA-WATER CHANNELS OF SOUTH CAROLINA AND GEORGIA, INCLUDING SOUNDS, HARBORS, AND RIVERS.—(SKETCH No. 10.)

Coast Pilot.—In this section, Assistant J. S. Bradford, in the schooner Palinurus, examined, with reference to safe lines for navigation, all the harbors between Georgetown, S. C., and Savannah. His notes made in the course of the season will appear in a subsequent volume of the Coast Pilot, of which the first volume has been some time in hand for publication. After visiting and inspecting the entrances of Winyah Bay, Bull's Bay, Charleston Harbor, Stono Inlet, North Edisto, Saint Helena Sound, Port Royal Sound and its rivers, and Savannah River, and verifying the sailing directions, Mr. Bradford returned to Norfolk at the end of April, and subsequently was engaged in Section II.

Cape Fear Entrances, N. C.—After the examination made in the latter part of May, Subassistant Vinal thus reports in regard to changes which have occurred in the vicinity of Cape Fear: "The changes have been rapid and extensive. Attention was paid, however, particularly to sounding the western channels, as required by instructions. The Bald Head or 'Seward' Channel preserves nearly the same position and direction as in 1873, and shows a little improvement in depth. To mark the best water now, buoy No. 3 should be moved fifty meters due west, and buoy No. 2 three hundred meters west-northwest, of their present positions.

"Some of the largest vessels for Wilmington, N. C., commenced using this channel in the spring of the present year."

Subassistant Vinal noted on the hydrographic sheet slight changes of a local nature which he found in the Oak Island channel.

"The reconnaissance in May shows that the shore-line at Bald Head Point has changed considerably. A shoal is making out from the point in the direction of the old jettee, and has already closed the slue shown by the survey of 1872. Farther down along the western shore of Smith's Island, the 'Finger' Shoal was found bare at half-tide for a considerable distance, and was connected with the shore, entirely closing the slue that formerly existed."

"The deflecting jettees at Federal Point and the breakwater, now finished between Teek's Island and Smith's Island, are shown on the hydrographic sheet. Several breaks have occurred in the long, narrow strip of land attached to Smith's Island. One of these is about an eighth of a mile wide, and seemed to have a constant channel, not being dry at low water."

"The New Inlet Channel through the Caroline Shoals, shown by the survey of 1872, is not now in use, though the buoys still remain in place, as marked on the sheets of that survey."

"A new channel, not buoyed, has broken through the shoals about one-half mile to the eastward of the old one, and is constantly used by small vessels."

"The strong eddy-current, caused by the works at Federal Point, has worn that point very much. Teek's Island, on the contrary, is larger than it was in 1872; the shoals on the eastern side, bare at half-tide, being quite extensive."

Mr. Vinal closed work in this section on the 1st of June, and, as soon as practicable, returned the schooner Bowditch to Norfolk. That vessel being no longer sea-worthy, the party was transferred to the schooner Bibb, and was engaged during the summer in service which has been mentioned under the head of Section II. The statistics of the hydrographic examination at Cape Fear are:

Miles run in sounding	55
Angles measured	514
Number of soundings	4,647

Topography of the vicinity of Cape Romain, S. C.—In continuation of his survey of the vicinity of South Santee River, Assistant W. H. Dennis resumed field-work in this section on the 1st of January, and extended the topographical survey of the coast southward and westward to include Cape Romain. The detailed work embraces all the water-courses adjacent to the coast-line, among which are Romain River and Oyster Bay, and also the topographical features of the ground lying east of the main road from Georgetown to Charleston, S. C. The channels which appear on the plane-table sheet form part of the inland passage between Charleston and the Santee River, and are much used by small steamers and trading-vessels.

Field-work was continued until the 20th of April, when the schooner Caswell, which had been used for transportation, returned with the party to Norfolk, and was subsequently in service in Section I, where also Assistant Dennis was engaged during the summer. He was aided in both sections by Mr. S. N. Ogden. The following are statistics of the survey near Cape Romain:

Miles of shore-line traced, coast, rivers, and creeks	328
Miles of marsh-outline	74
Miles of roads	79
Area of topography (square miles)	112
Miles run in sounding	230
Angles measured	1,668
Casts of the lead	29,390

The plane-table sheet, which adjoins the survey here under notice, and on which Assistant Dennis had traced the outlines of rice-fields as they appear in the vicinity of North Santee and South Santee Rivers, was reproduced by photolithography in the course of last winter. The fidelity, accuracy, and finish of the map are specially mentioned by the residents to whom the few copies printed were sent. In one of the acknowledgments is the following remark: "This accuracy is the more surprising when it is considered that on two-thirds of the rice-field the banks are overgrown with weeds and briers. The results shown on the map could not have been attained without the most unremitting industry, patience, and skill on the part of Mr. Dennis and his aid."

Astronomical observations at Savannah, Ga.—The astronomical station at Savannah was occupied in the spring of the present year by Assistant F. Blake, for the exchange of clock-signals, to determine the longitude of points on the western coast of the Florida Peninsula, of which special mention will be made in the next chapter. At the same time, the occasion was taken to determine finally the longitude of Savannah by the exchange of clock-signals with the United States Naval Observatory at Washington, D. C., at which the observations were conducted by Professor Harkness and Professor Eastman.

The aid in the party at Savannah, Mr. Charles Tappan, recorded observations from January 26th until the 3d of April. In that interval, Mr. Blake exchanged clock-signals on six nights with the Naval Observatory; on four nights, with an observer who sent signals by telegraph from a station at Punta Rasa, near the entrance to Charlotte Harbor; on five nights, with the same observer when at Cedar Keys; and on six nights, when the observer, Subassistant Edwin Smith, occupied a station at Atlanta, Ga. For clock and instrumental corrections, 340 star-transits were observed at Savannah by upward of 5,000 observations. Assistant Blake determined relative personal equation with the Washington observers on three nights in April at the Naval Observatory. The personal equation relative to Mr. Smith had been previously determined.

Telegraphic facilities, free of charge, for the determinations made in this section and Sections VI and VII, were afforded by John Van Horne, esq., superintendent of the Western Union Telegraph lines, whose name in preceding reports has been associated with similar instances of enlightened liberality. The field-report mentions also the courteous generosity of T. A. Brenner, esq., division superintendent of the telegraph company; and of the Hon. D. L. Yulee, superintendent of the Florida Railroad, by which the several telegraph circuits requisite for the astronomical work were placed at the disposal of Assistant Blake. Since the return of the party in April, Mr. Blake has been engaged in computing results from the records of observations made for determining longitude in the previous season. Mr. Tappan was, at the same time, assigned to field-service, of which mention will be made under the head of Section VII.

Special survey of Savannah River, Ga.—The call made last year by the city authorities of Savannah for a special survey of the river, with reference to the application of means for improving or preserving the channel, was met by the assignment of Assistant Charles Hosmer, with a party in the schooner G. M. Bache. Field-work was commenced on the 10th of December, 1873, and was continued until the 1st of May. The intended scale of the survey being large, triangulation was extended from Tybee light-house upward to include about twenty miles of the course of the river, and to furnish points sufficient for detailed plane-table work. Between "Cross Tides" and Elba Island, the survey was made on a scale of $\frac{1}{2400}$; and that stretch of the river is represented by four sheets. Below Elba Island, three sheets, on a scale of $\frac{1}{5000}$, extend the work to include Tybee Light-House.

Assistant Hosmer was aided in field-work and hydrography during the season by Mr. J. De Wolf, and, after the 16th of January, by Mr. W. E. McClintock. The following is a synopsis of statistics from the plane-table and hydrographic sheets:

Signals erected	28
Stations occupied	24
Angles measured	197
Number of observations	1,608
Miles of shore-line traced	83
Miles run in sounding	163
Sextant angles	4,417
Number of soundings	25,216

After computing and depositing at the office the results of his survey of Savannah River, Assistant Hosmer resumed field-service in Section II. Early in May, Mr. McClintock rejoined the party of Assistant C. S. Peirce, in which he had been employed during the early part of the preceding winter.

As bearing directly upon the practicability of preserving or improving the river-channels, the physical features of the lower part of the Savannah were examined by Assistant H. L. Marindin, under the general direction of Assistant Henry Mitchell, who could not personally attend for this duty, being in the spring engaged in public service on the Isthmus of Darien.

In accordance with a plan of work previously arranged, Mr. Marindin, in May, made simultaneous observations in the vicinity of Tybee Knoll along six transverse lines, noting the currents at five or six stations in crossing the channels. The currents were also observed at stations between transverse lines. Catch-boxes were placed in order to determine the source and character of the material which is deposited by the action of tides and currents on the bar. One of these, two weeks after being sunk, was found to be nearly full of material that had found way in at different times, the solid matter being in well-defined layers. In this particular case, which is noted merely for its general connection with similar researches that may be needed elsewhere, soft mud or sediment from still water was found in the bottom of the box, and, above that material, fine and coarse layers of sand, then layers of dead vegetable matter, and again sand and mud; the deposit in the box having evidently resulted from varying agitations of the water at the bottom of the river. The observations recorded by Mr. Marindin will suffice for deriving transverse curves of velocities, and by such means to show the effect of the shoals on the currents near the light-house, as well as any present tendency in the currents to change the physical features that now mark the bar. The dredging operations of the engineer department on Tybee Knoll have probably directed part of the current in that vicinity through a new channel, as the subcurrent-floats, set by Mr. Marindin, seemed to be deflected inward from both sides of the channel.

Amongst the questions pending for the improvement of the channel of the river is the practicability of diverting into Fore River, above the city, part of the volume of water that now passes through Back River. Such observations as may be requisite for determining the question will be made, if possible, in the coming winter.

Assistant Marindin used the schooner Research for the work in Savannah River, and, as already stated under the head of Section II, was engaged in similar service during the summer.

SECTION VI.

ATLANTIC AND GULF COASTS OF THE FLORIDA PENINSULA, INCLUDING THE REEFS AND KEYS AND THE SEAPORTS AND RIVERS.—(SKETCHES NOS. 11 AND 12.)

Fernandina Bar, Fla.—In the latter part of January and early in February, the entrance to Fernandina was examined by Subassistant F. D. Granger with a party in the steamer Endeavor. At that period, as at all times generally, the best water that could be carried over the bar at mean low tide, was eleven feet. In reference to the results of this and previous examinations, Mr. Granger reports: "The soundings taken this season show two channels over the bar, which are separated by a central knoll of 7½ feet, the northern or buoyed channel being the wider. In the southern channel, the width of the bar between the 12-feet curves is eighty-five yards, while, in the buoyed channel, the width is about four hundred yards."

In the survey of 1869, the channel over the bar was found to have thirteen feet of water, but that depth is not permanent. The channel then in use soon shoaled at the turning-point, and was abandoned; its buoys and beacons being transferred to the channel as it is at present. In February, the guides to navigation were found to be correctly located with reference to this channel.

In the middle of April, Mr. Granger, having advanced the coast-hydrography southward of Saint John's River Entrance, returned to Fernandina, and commenced a close survey of the bar. A tide-staff was set up at Old Town, and a mark on it was referred by leveling to the bench-marks used for the survey of 1870. The currents were observed at six stations. No changes of importance were developed by the soundings. As compared with those of February, the depth on the bar was the same, giving eleven feet as the best water. At each of the current-stations, specimens of bottom were procured, showing that the bar is composed of fine and coarse sand mixed with

small shells. As a result of the several examinations of this bar, it appears that heavy easterly storms tend to change the direction of the channel, but without affecting an average depth of eleven feet on the bar. The greater depth found has not been in any case long maintained.

Subassistant C. P. Dillaway was attached to the hydrographic party in the steamer Endeavor, and Mr. D. C. Hanson served as aid. Under the next head, mention will be made of the further operations of the party.

Atlantic coast of Florida, in-shore soundings.—On the 10th of February, the party in the steamer Endeavor reached Mayport. Subassistant Granger, finding no marks of the previous triangulation on Diego Plains below the mouth of Saint John's River, erected a large signal on Saint John's Point, and determined its distance from the light-house by observing on a signal which he had set up at an identified station on the north side of the entrance. Using the line so determined as a base, the coast-triangulation was renewed, and intervening signals were ascertained in position to a point about midway between the Saint John's and Saint Augustine. These preliminaries were completed by the 13th of March. Soundings were then commenced at Saint John's River Entrance, and were continued until the 9th of April. Lines run seaward eight and a half miles were crossed by others that develop the coast-hydrography for about sixteen miles below the entrance of the Saint John's. In reference to the nature of the coast-approach of this part of the Florida Peninsula, Mr. Granger remarks: "The most noticeable characteristics shown by the soundings are a series of ridges parallel with the beach-line, commencing several miles from shore; the difference between the depths on and off the ridges being several feet." The tides were recorded at Mayport while the party was engaged in soundings along the coast.

As already mentioned, Mr. Granger returned to Fernandina, and made a careful survey of that bar in the latter part of April. During the summer, he was engaged in service which has been mentioned under the head of Section I.

The statistics of the working-season which closed in May last are:

Miles run in sounding	522
Angles measured	4,267
Number of soundings	18,542

Survey of the Atlantic coast near Mosquito Inlet, Fla.—Field-work in this section was resumed early in January by Assistant A. M. Harrison, who, as in the previous season, was preceded by his aid, Mr. W. H. Stearns, to provide points by triangulation for continuing the detailed survey. As results of the operations which closed for the season on the 15th of May, two plane-table sheets and seven others filled with soundings were returned to the office. These represent the topography of the shores of Halifax River and Hillsboro' River, including also Mosquito Inlet, at which the two estuaries unite, and the Atlantic coast adjacent to the inland waters just named. A stretch north and south upward of thirty miles is included in the survey of this year. Six tidal stations were occupied in the course of the season; one of them for a period including the summer, fall, and winter of 1873, and part of the spring of the present year. At these stations, simultaneous observations were recorded, so that, if needful, all the results can be readily referred to the tide-gauge which remained longest in use.

Assistant Harrison was aided in this section, and also in Section I, by Mr. Bion Bradbury. As heretofore, the party used the sloop Steadfast for quarters and for transportation in the survey near Mosquito Inlet. The Light-House Board, having immediate need for a map of that entrance, has been furnished with a tracing from the sheet which includes it. The general statistics are:

Signals erected	31
Stations occupied	31
Angles measured	181
Number of observations	2,376
Miles of shore-line traced	307
Miles of roads	75
Area of topography (square miles)	120
Miles run in sounding	174
Sextant angles	389
Casts of the lead	24,641

Longitude-observations at Key West and Punta Rasa, Fla.—Subassistant Edwin Smith left New York early in December, 1873, for duty in this section, and made needful arrangements at Key West for exchanging clock-signals with the Naval Observatory in Washington City. Exchanges of signals were begun on the 24th of December, and were repeated on seven nights preceding the 11th of January. In that interval, Mr. Smith, and his aid, Mr. J. B. Baylor, recorded two hundred and eleven observations on thirty-eight stars, to determine instrumental constants and errors of chronometers. The observations made at Key West were referred to Tift's Observatory.

Mr. Baylor left Key West on the 21st of January to make arrangements for determining the longitude of a point in the triangulation of the west side of Florida Peninsula at Punta Rasa, and was followed by Subassistant Smith at the end of the month. Clock-signals were exchanged on four nights with Assistant Blake, who occupied a station at Savannah, as already mentioned under the head of Section V. Observations for determining instrumental constants and errors of chronometers were recorded as usual at Punta Rasa. This work was completed at the end of February. After carefully marking at Punta Rasa the point which was determined in longitude, Subassistant Smith and Mr. Baylor proceeded to Cedar Keys for service that will be stated under Section VII.

Triangulation and topography of Tampa Bay, Fla.—This work has been continued by Assistant H. G. Ogden, with a party in the schooner Agassiz. At the outset of the season, in the middle of December, 1873, operations were prosecuted by Mr. D. B. Wainwright, the aid, in the absence of the chief of the party, who was detained by field-work in another section. Mr. Ogden reached the site of work on the 1st of February, and, under disadvantages due to the weather which afterward prevailed, pushed the triangulation, as far as practicable, up the bay. The topography meanwhile was advanced along the east shore from Anna Maria Key northward to a station about six miles below Mangrove Point. Palmasola Bay, Manatee River, and Terraceia Bay were included in the plane-table survey. In referring to the operations in this quarter, Mr. Ogden remarks: "The shores are much broken, and many of the small bays and coves cannot be entered with a boat at low water. In April, a contrary difficulty was experienced; the water being so high that much of the country was submerged. Hence it was impossible to define the sand-bars or low-water line, and in many places the high-water line could be only approximately traced."

In April, Assistant Ogden measured a check-base on Anna Maria Key, and found a satisfactory result by comparing it with the length derived by computing through the triangulation from the base at Clearwater Harbor. Eight signals were erected by the party in the course of the season for extending triangulation over Tampa Bay. On closing work at the end of April, the plane-table statistics were:

Miles of shore-line traced	152
Miles of marsh-line	10
Miles of roads	21
Area of topography (square miles)	54

As already mentioned, the field-season at the North was passed by this party in Section II; but, in autumn, Assistant Ogden will again resume the survey of Tampa Bay.

Hydrography of Tampa Bay, Fla.—The party of Subassistant Andrew Braid, in the schooner Speedwell, reached Tampa Bay in the middle of December, 1873, and, as soon as practicable, put up and determined the signals requisite for continuing the hydrographic survey. Two tide-gauges were erected, one at Egmont Key, the other at Hendrick's wharf in Manatee River, and at both stations observations were recorded while soundings were in progress.

The work of this year, on three sheets, extends the hydrography of Tampa Bay to a point somewhat beyond the present limit of the triangulation, or from the entrance upward as far as Mangrove Point. Manatee River was sounded by the party, and also the branches known as Terraceia Bay, Palmasola Bay, and Sarasota Bay. The work was discontinued at the end of April. Messrs. C. A. Ives and C. H. Sinclair served as aids in this section, and subsequently in Section II, where Subassistant Braid was engaged during the summer. On closing work in Tampa Bay, the schooner Speedwell was laid up in Manatee River. The following is an abstract of statistics from the hydrographic sheets:

Miles run in sounding	1,205
Angles measured	6,530
Number of soundings	91,400

Early in the season, hazy weather, and later, the prevalence of heavy winds, somewhat impeded hydrographic operations; but the results show a satisfactory advance in the survey.

SECTION VII.

GULF COAST AND SOUNDS OF WESTERN FLORIDA, INCLUDING THE PORTS AND RIVERS.—(SKETCH No. 13.)

Longitude-observations at Cedar Keys, Fla., and at Atlanta, Ga.—As stated in the preceding section, Subassistant Edwin Smith, and his aid, Mr. J. B. Baylor, observed for longitude by exchanging clock-signals from stations at Key West and at Punta Rasa; the last-named station being at the entrance to Charlotte Harbor, on the western coast of the Florida Peninsula. After completing these operations, the party proceeded to Cedar Keys, and there set up a temporary observatory, and mounted the requisite instruments. Between February 27 and the 8th of March, clock-signals were exchanged on five nights with Assistant Blake, who remained at Savannah; and ninety-five observations were recorded on eight nights by Messrs. Smith and Baylor, to determine chronometer-rates and instrumental constants. The observations made at Cedar Keys were referred to the station which marks the north end of the base-line measured in a former year for the survey of that part of the Gulf coast. Facilities for the accommodation of the party were furnished from the outfit of Assistant Mosman, who was then in camp near Cedar Keys.

Leaving Cedar Keys on the 11th of March, Subassistant Smith reached Atlanta in the course of three days, but was prevented by a long-continued storm from observing for longitude until the 19th of that month. Between the 19th and the last of March, clock-signals were successfully exchanged with Assistant Blake on six nights. In the same interval, eighty-five observations were recorded on seventeen stars for instrumental constants and chronometer-rates. At Atlanta, the observations were made, by permission of the mayor, Hon. S. B. Spencer, at a station in the city-hall square. The granite block which had supported the transit-instrument was left in place, marked with the latitude, and will be marked also with the final value for longitude after the computed results are known. About one hundred yards south of the astronomical station, a granite post was firmly fixed to mark the true meridian at Atlanta. The observations there were referred by careful measurement and computation to the spire of the city-hall, which is one of the geodetic stations already connected with the base-line near Atlanta.

Subassistant Smith reported at the office early in April. After observing for personal equation at the Naval Observatory, preparation was made for his departure in the United States steamer Swatara, in which vessel he sailed on the 10th of June with others to observe the transit of Venus at Chatham Island in the South Pacific Ocean.

In order to make available for geographical purposes the determination of longitude at Cedar Keys, it was found needful to renew the triangulation in that quarter. Of the station-points, all of which were carefully marked in the usual way previous to the outset of the late war, Assistant A. T. Mosman, who was detailed for the service, reports that none remain, except the two screw-piles which mark the ends of the base-line. At the northern end of the base, the screw-pile was found to be inclined at right angles to the direction of the line measured and marked in 1857. Mr. Mosman was on the ground on the 24th of December, 1873, and began field-operations early in January. In succession, he occupied stations east and west of the base, and completed the triangulation from Pelican Shoal and Black Point to Waccasassa Reef. Azimuth was determined at the station on Depot Key. Having extended the work as far as practicable from his camp, Mr. Mosman closed operations in this section on the 20th of March. The statistics are:

Signals erected	15
Stations occupied	15
Angles measured	67
Number of observations	4,422

For the azimuth, thirty sets of observations on Polaris were recorded on eight nights; and, for time, twenty-four sets of double altitudes of the sun, observed with the sextant and artificial horizon, were recorded on thirteen days.

Assistant Mosman was aided in this section, and also in service which has been mentioned under Section III, by Mr. D. S. Wolcott.

On the 1st of April, Mr. Mosman left Cedar Keys, and passed along the line of railroad to Fernandina, to make report upon the expediency of continuing triangulation across the head of the Florida Peninsula. Of about one-half of the field-work done previous to 1861, the records never reached the office; the volumes which contained them being in charge of an officer of the Regular Army who remained in the Southern States during the war. The conclusion reached at the return of Assistant Mosman, after a careful review of the present condition of the work and of estimates for resuming it, was that, though very desirable for the verification of geographical points, at which independent determinations have been made on the Atlantic coast and Gulf coast, the requirements of the service elsewhere are at this time more pressing.

Triangulation from Cedar Keys to Saint Mark's, Fla.—For defining the general line of the Gulf coast northward and westward of Cedar Keys, a party was sent in December, 1873, under the direction of Subassistant F. W. Perkins. Field-work was begun at the end of that month, and was prosecuted until the 9th of May. The schooner Torrey, which was used for this work, then sailed for Apalachicola, and was laid up for the summer.

Much difficulty was overcome in the selection of a base-line, but finally Mr. Perkins chose a stretch of the coast with level rock bottom. It is entirely covered by water during northerly winds, but is dry at low water. The line will be measured in the course of the coming winter.

For the triangulation, water-signals were placed by the party at points averaging about three miles from the coast-line. These were observed on with the theodolite from shore-stations; horizontal angles being measured at three, on each of the water-signals.

The azimuth of a line about midway between Cedar Keys and Saint Mark's was determined by observations with a 12-inch theodolite on Polaris during five nights, on which an aggregate of four hundred and fifty-six pointings on star and mark were recorded, as were also twenty-three sets of observations for time. The general statistics of the triangulation are:

Signals erected	22
Stations occupied	19
Points determined	27
Angles measured	114
Number of observations	6,022

Subassistant Perkins was aided in this section, and also in Section I during the summer, by Mr. F. W. Ring.

A party will be organized for completing the shore-line survey and hydrography between Saint Mark's and Cedar Keys.

Hydrography of Saint George's Sound, Fla.—For completing the hydrography of the western approaches, and developing the shoal ground off Point Saint George, the party of Assistant H. Anderson sailed for Apalachicola, on the 12th of January, in the schooner Silliman. Two days after leaving Portland, the vessel was disabled in a heavy gale, but fortunately reached Nassau, at which port, by the prompt intervention of the United States consul, Mahlon Chance, esq., needful repairs enabled the party to proceed in the schooner to her working-ground, where she arrived on the 9th of March. Assistant Anderson put up a tide-gauge near Saint George light-house, and erected signals for the hydrography of that vicinity. After full preparation, the vessel remained several days at West Pass; but, as the weather was constantly boisterous, the party was transferred to Saint Vincent Sound. By the 10th of April that sound was developed. The resulting sheet shows that it is a large shallow bay filled with oyster-banks, and having on the bar at the inlet only about four feet of water.

Returning to West Pass in the middle of April, Mr. Anderson succeeded in running lines of soundings across the shoals off Saint George's Point, and in filling up the spaces not previously sounded in the Gulf approach to West Pass. The season's work was closed on the 8th of May. A

few days after, the schooner left Apalachicola to return to Portland, and, without mishap, reached the vicinity of Cape Fear. There, however, the mainmast was shattered by lightning on the 25th of May; and, in a squall next day, the head of the foremast was twisted off. Fair winds succeeding, the Silliman reached Baltimore without further delay, and was there furnished with masts. The statistics of hydrographic work done by the party in this section are:

Miles run in sounding	246
Angles measured	1,095
Number of soundings	18,076

Assistant Anderson was aided in this section, and also in Section I, where he was engaged during the summer, by Mr. F. H. North. Messrs. G. A. Morrison and Charles Coburn also served as aids in the work near Saint George's Sound.

Atlanta base-line.—It was intimated in the last annual report that operations in direct connection with the base-line near Atlanta, Ga., would be concluded by the determination of the height of the base-site, above the level of the sea. In December, 1873, after closing observations at Stone Mountain, Assistant C. O. Boutelle organized a party to run two lines of levels from the station-point on the mountain to a bench-mark in the village, of the same name, on the line of the Georgia Railroad. In January, the levels were carried one hundred and fifty-six miles along the railroad-line to Augusta, Ga. The aids entrusted with this work, Messrs. H. W. Blair and J. B. Boutelle, determined the levels by moving from village to village; no facilities in transportation being available.

At Augusta, the levels were connected with those of the recently-constructed Port Royal Railroad from Augusta to Beaufort, S. C. The officers of this road placed their note-books at the disposal of Assistant Boutelle, and careful examination proved that such as related to differences of level could be relied on.

Tidal observations were made by the party at Beaufort, to determine the "mean level of sea," and that plane was carefully connected with the levels of the Port Royal Railroad; thus giving a connected series from tide-water to the top of Stone Mountain, a distance of two hundred and sixty-seven miles.

The height of Stone Mountain was referred to the Atlanta base-line by hypsometric triangles, with reciprocal zenith-distances from the base termini. The results of the several operations show that the height of the base-line above the mean level of the sea is 1049.2 feet.

At the opening of the present fiscal year, Assistant Boutelle occupied Grassy Mountain station, and is there engaged with his party.

Triangulation in Georgia.—At the date of the last annual report, Assistant F. P. Webber was at Carnes Mountain, a station to the westward of the Atlanta base-line. The measurement of horizontal angles there was completed by the end of the year, when the camp-equipage was stored at Cartersville. Mr. Webber completed his computations and other office-work in the course of the winter, and in March accompanied Assistant McCorkle for the selection of additional stations to the northward and westward of Atlanta. Before leaving Carnes station, the party had erected a signal on Indian Mountain. Early in June the triangulation was resumed. A signal was set on the highest point of the Cohutta Mountains, a work of much labor. No house being within reach, the party, during an entire week, while engaged in this duty, had no shelter at night excepting the trees on the mountain. Next in order, John's Mountain was visited, and marked by a signal in the latter part of June. Further progress made by this party will be mentioned in the report of next year. Messrs. J. H. Christian and Charles Tappan have served as aids in the party.

The connection of the Atlanta base-line with triangulation in its immediate vicinity is shown on Sketch No. 9.

Reconnaissance.—While other operations were in progress for the geodetic connection, reconnaissance was made by Assistant S. C. McCorkle for stations to extend the work northward and westward, in order to join with points along the Tennessee River. After examining the Lookout Mountain range, Mr. McCorkle went farther westward early in March, and noted Chandler's Mountain, and near it Aurora, both in Alabama, as points suitable for the purposes of the triangulation. Three points in the Lookout range, intermediate between Chattanooga and Chandler's

Mountain, were selected, and others to the eastward and westward of the range, sufficient for the prospective triangulation from the Atlanta base to the Tennessee River. The report of Mr. McCorkle, presented early in July, after his return from the field, is accompanied by full notes in regard to relative heights, and such particulars in reference to the selected stations as could be gathered by close local inquiry. In the middle of July, after reporting in person at the office, he took the field for reconnaissance in Section III, as stated under that head.

Reconnaissance.—Assistant R. E. Halter, at the opening of the present fiscal year, was directed to examine the vicinity of the Ohio River between Wheeling and Cincinnati, in order to determine the practicability of conducting a chain of large triangles westward. Further mention, including the results of his reconnaissance, will be made in my next report.

SECTION VIII.

GULF COAST AND BAYS OF ALABAMA AND THE SOUNDS OF MISSISSIPPI AND OF LOUISIANA TO VERMILION BAY, INCLUDING THE PORTS AND RIVERS.—(SKETCH No. 14.)

Survey of the Mississippi River at New Orleans, La.—Assistant C. H. Boyd organized his party and was on the working-ground near New Orleans in the middle of December, 1873, with the schooner Varina. The plan of the season had in view a second party to work with the schooner James Hall, for completing the topographical survey of the Mississippi as far up as New Orleans; but Subassistant Hergesheimer, who was assigned to that service, was prevented by serious illness from taking the field. In consequence, the operations were limited to triangulation and hydrography.

Assistant Boyd resumed field-work near the battle-ground of 1814, and, after connecting stations along the river with points in New Orleans, occupied others for perfecting the survey to Carrollton, and for including the shores of Lake Pontchartrain and Lake Borgne; triangulation having been pushed through the last-named lake in 1853. In the operations of this year, three avenues were cut through cypress-swamp that intervened between stations, an arduous work, the completion of which by an ordinary field-party is evidence of great courage and perseverance in the chief and in the men employed. Some of the intervening trees being more than one hundred and fifty feet high along one of the lines of sight, in order that the labor in their removal might be the least possible, Mr. Boyd determined the direction of the line, which is seven and a half miles long, by sending up rockets, to be observed with the theodolite from the station at which the line terminated.

Mr. C. H. Van Orden joined the party on the 26th of December. The hydrography was then resumed at English Turn, twenty-two miles below the city, and was continued uninterruptedly to Carrollton, ten miles above New Orleans. By this judicious action, soundings were completed before the time of freshets and maximum currents had set in. Assistant Boyd found at New Orleans a depth of thirty-six fathoms, and that the river-current was, at some of the stations, as much as four miles per hour. At the conclusion of work on the 15th of May, the schooner Varina was laid up at the Head of the Passes. The following are statistics of the work:

Signals erected	13
Stations occupied	18
Angles measured	312
Number of observations	4,896
Miles run in sounding	200
Sextant-angles	2,308
Number of soundings	4,055

For the adjustment of soundings, tidal observations have been recorded during the entire year at New Orleans. The currents were observed at six stations.

Early in the summer, Mr. Boyd completed at Portland the office-work and computations pertaining to his survey of the Mississippi, and then resumed field-service.

Tidal observations.—At New Orleans, La., a series of observations has been kept up by recording the rise and fall on a tide-staff. The observer, Mr. G. Faust, notes the height of the water

every six hours, commencing at midnight. Daily tides at the city are very small, and have been recorded mainly because of their connection with periodical floods in the Mississippi.

The self-registering tide-gauge sent to Saint Thomas, West Indies, at the request of Colonel W. Thulstrup, of the Royal Danish Engineers, has continued in operation, and since July, when that officer left the island, has been in charge of M. Kruse. The records received at the Coast Survey Office show that the continuity of observations has been well preserved. In time, this series will furnish valuable data bearing on a study of the formation, progress, and changes of the tidal wave.

Triangulation in Missouri.—Early in the present fiscal year, Assistant C. H. Boyd resumed field-work in Missouri, aided by Mr. C. H. Van Orden. The details of the work done will be noticed in my report of next year, in which report will be included all field-work commenced after the 1st of July of the present year.

Reconnaissance for triangulation in Wisconsin.—Professor John E. Davies is now in the field with a view of selecting stations for triangulation; the object being to determine points for correcting the State map, and thus to afford a reliable basis for representing the results of the geological survey of that State. Further mention of this work will be made in my report for next year, which will include notices of all the operations commenced after the 1st of July of the present year.

SECTION IX.

GULF COAST OF WESTERN LOUISIANA AND OF TEXAS, INCLUDING BAYS AND RIVERS.—(SKETCH No. 16.)

Triangulation and topography of Sabine Pass, Tex.—For this survey, Subassistant J. N. McClintock was assigned to duty, and early in January his party arrived at Galveston. After measuring a base-line, eight stations were occupied with the theodolite, at which seventeen points were determined in position for use in the plane-table survey. Mr. J. F. Platt served as aid in the field-operations, which continued until the opening of June, when the party was transferred for service in Section I. The following statistics relate to the work at Sabine Pass:

Stations occupied	8
Angles measured	64
Number of observations	2,052
Miles of shore-line traced	22
Miles of creeks and ponds	14
Miles of roads	5

Of the region in which the party worked, Mr. McClintock says: "The country is generally very wet, but little above ordinary high-water level, and liable to overflow. One peculiarity of the Pass is, that from the entrance and to the westward for about ten miles, the water and mud of the river form a kind of thin mortar. Vessels seek a harbor in this sea of mud, which is commonly known as the *Oil Spot*, and are safe in heavy gales, the mixture being too stiff to break at the surface with the force of the wind."

Hydrography of Pass Cavallo and of San Antonio Bay, Tex.—For this service the party of Subassistant L. B. Wright was organized in the latter part of December, 1873, and commenced soundings early in the following month in San Antonio Bay. A small craft was chartered for that work; the schooner Stevens not being available on account of her draught of water. After sounding the main body of San Antonio Bay, a hydrographic resurvey was made of the bar of Matagorda Entrance, including the channel known as Pass Cavallo, where the operations were closed for the season at the end of the fiscal year. The following are statistics of the work:

Miles run in sounding	759
Angles measured	5,599
Number of soundings	55,075

Messrs. A. G. Pendleton and E. H. Wyvill served as aids in the hydrographic party.

After his return from the coast of Texas, Subassistant Wright was engaged in Section II. Mr. Pendleton was at the same time assigned to service in an astronomical party, and Mr. Wyvill took charge of the hydrographic party in Lake Champlain when Assistant Junken was too ill to conduct its operations.

SECTION X.

COAST OF CALIFORNIA, INCLUDING THE BAYS, HARBORS, AND RIVERS.—(SKETCHES Nos. 17, 18, 19.)

The long acquaintance of Assistant George Davidson with local interests and requirements on the Pacific coast has enured as in former years for the prompt development of any part of the seaboard likely to be reached by the advance of settlers. While providing for the earlier prospective requirements, due forethought has been given to the many local surveys, so as to form continuous charts of the coast of California and Oregon, and of Washington Territory. The Western Coast Pilot or Directory, first compiled by Assistant Davidson, has in successive editions embodied the valuable particulars which he gathers for permanent record. In addition to his duties as chief of a field-party, the results of his large experience and observation have been cheerfully given in the selection of localities of work for the other parties, so as to make most effective the means available for the development of the western coast.

As chief of one of the parties to be sent out under the direction of the honorable Secretary of the Navy, to observe the transit of Venus in December next, Assistant Davidson, accompanied by Subassistant O. H. Tittmann, came east from San Francisco, and in May last conferred personally, at Washington City, with other observers who had been assigned for the same service. Messrs. Davidson, Tittmann, and Edwards sailed from San Francisco on the 29th of August, and are now engaged at Nagasaki, Japan, in making observations preliminary to such as will be noted during the transit. Mr. Thomas P. Woodward, aid in the Coast Survey, and heretofore in service on the Pacific coast, was assigned to accompany the party of Prof. J. C. Watson, for observing the transit of Venus at a station near Pekin in China.

Much of the work of which mention will be made in the following abstracts is in progress in the field while this report is closing. Hence, as the field-reports cannot reach the office in time to admit of being embodied in my report for this year, mention only in such cases will be made of the localities in which work is now in hand, and for which the statistics will be given in the next annual report.

Rock off Point Loma.—In a close examination, made at the instance of Assistant Davidson, by the aid of the hydrographic party of the schooner Marcy, Mr. Frederick Westdahl, the sunken rock off Point Loma was found to have in depth two fathoms less water than had been previously reported. The least depth, six fathoms, is in the edge of the kelp, and, being out of the course followed by steamers, cannot be regarded as a danger. Nevertheless, Mr. Westdahl ascertained that the water had been seen to break in that locality. He accordingly determined the position of two stations, which he connected with the neighboring triangulation, and instructed the light-keeper in regard to erecting ranges for determining the exact place of least water when the break is next visible.

Triangulation and topography of Santa Ana River, Cal.—This survey by Assistant A. W. Chase defines about eight miles of the main coast of the Santa Barbara Channel below Bolsas Creek, which is also included on the plane-table sheet. Farther on, to the southward and eastward, the survey of the present year embraces several miles of the course of Santa Ana River and all details of the coast-topography within an average distance of a mile and a half from the water-line.

When Mr. Chase, in the latter part of February, took the field, the great marshes of the Bolsas and Santa Ana were overflowed by freshets. Crossing was dangerous on account of the quicksands, and the muddy roads near the coast were almost impassable. This condition was due to the unusual rain-fall (28 inches) during the winter. Under such impediments, Mr. Chase passed the time in reconnaissance, and completed at Anaheim the large amount of office-work which resulted from his field-operations of the previous year, and in which he had been steadily employed during the winter at San Francisco. As late as the 9th of March, when the triangulation was in progress, skiffs were required for passing the sloughs of the Santa Ana and Bolsas. In selecting stations, points near the coast, and requisite for the plane-table survey, were chosen, so as to admit of ready connection with stations on the nearest mountain-range. One of the points thus selected is a peak over 1,100 feet high, on the San Joaquin Mountains, and from which the observer has in view the

cliffs at San Juan Capistrano. In the course of the triangulation, fifteen signals were set up, twelve stations were occupied, and forty-four angles were measured by six hundred and seventy-two repetitions. At two of the stations, observations were recorded for determining the positions and heights of the principal peaks of the Sierra Madre Mountains. The computed results give for the average height of the mountain-chain from 8,000 to 9,000 feet, and for the highest peak, San Antonio Mountain, an elevation of 10,000 feet above the level of the sea. In the topographical survey, which includes eleven and a half square miles, and within which eighteen miles of river-shore lines were traced, the contour-lines were all run out with a level. In reference to the wharves built by residents of Anaheim, at whose request tracings of the shore-line survey and soundings near the mouth of Bolsas Creek had been furnished, Assistant Chase remarks: "There seems to be no question, so far as the influence of the wind or sea may affect them, of the stability of these wharves; but they are rapidly giving way under the attacks of the *Teredo navalis*. In less than two years, the piles have been riddled by this destructive insect, despite all wood-preserving processes so far used on the coast-line wharves." Assistant Chase was aided in this survey by Mr. C. Uhlig.

In a communication addressed to me in June last, Mr. Chase suggests "a continuous application of a light quality of coal-oil or kerosene from above through the wood fibres of piles in wharves and piers, to prevent the *Teredo* from boring." The same expedient had been independently suggested by Assistant Davidson.

As these intelligent officers well know that large expense would be so entailed, their suggestion prominently brings into view the great drawback in maintaining ordinary marine structures as facilities for commerce on the Western coast. There are at this time on the open coast-line of the Pacific, within the limits of the United States, nine wharves, ranging from 800 feet to 2,200 feet in length, and severally costing from $18,000 to $30,000. Most of these structures have been of necessity erected so as to project into the open sea, and in such situations they are immediately attacked and are quickly destroyed by the *Teredo navalis*. At Hueneme, on the Santa Barbara Channel, all the piles of a wharf nearly 900 feet long, 40 feet wide, and 18½ feet deep at the outer end, were treated, when put in place only two years ago, by the most approved means then in use for preserving wood, and at great cost. This wharf is already giving way. Within the present season, the piles taken up for examination were found to be completely riddled by the worm. Assistant Chase states that as yet the *Limnoria* is known only in San Diego Bay. The *Teredo* is destructive at Santa Barbara, San Luis Obispo, and at Crescent City; the wharves at these places being specially noticed by Mr. Chase. At the last-named port, he observed that some of the piles had left in them only about half an inch of solid wood.

Triangulation and topography of Santa Cruz Island, Cal.—Subassistant Stehman Forney remained with his party in the field during the winter of 1873–'74, and prosecuted the detailed survey of the western end of Santa Cruz Island until the 1st of June of the present year. The progress of work was much impeded by the unusual amount of rain during the season and by prevailing fogs and winds. The statistics are:

Signals erected	22
Stations occupied	8
Objects observed upon	26
Number of observations	2,510
Miles of shore-line traced	17
Area of topography (square miles)	10

Hydrography of Santa Barbara Channel.—Commander P. C. Johnson, U. S. N., assistant in the Coast Survey, with his party, in the steamer Hassler, returned to San Francisco on the 19th of December, 1873, after extending the hydrographic survey of the Santa Barbara Channel, as was mentioned in the preceding annual report. The work in that quarter was resumed in May last, when opportunity was taken to run lines of soundings off shore to the depth of 500 fathoms from several points along the coast of California. Except at Point Pinos, where deep water approaches within eight miles of the land, the curve of 500 fathoms was found at about thirty miles from the shore-line. The lines run were started separately from San Miguel Island, Point Conception, Point

Buchon, Point Pinos, and Point Año Nuevo. Early in June, Commander Johnson was detached from service in the Coast Survey. The command of the steamer Hassler then devolved on Lieutenant-Commander H. C. Taylor, U. S. N., who in the preceding month, as executive officer, had conducted a search for the shoal which has been several times reported as existing to the southward and westward of the Farallones. Approaching the site from the northward, the vicinity was passed over by the steamer with suitable traverses, but no bottom was found with 200 fathoms in either of fifty casts of the lead.

July and August of the present year will be passed by the party in the steamer Hassler in prosecuting in-shore and off-shore hydrography near Crescent City. In this quarter, operations conducted at a site of work above the northern boundary of California will be referred to more in detail under the head of Section XI in my next annual report. At all favorable opportunities, the ocean-currents will be observed and recorded by the hydrographic party. The plan of work for the present season includes development of the curve of depth in 500 fathoms between Point Reyes and Cape Orford. Records of these operations have not yet reached the office; and hence the results will be reserved for mention in my next report.

Lieutenant-Commander Taylor is ably assisted in hydrographic duty by Lieutenants George S. Talcott, Frank Courtis, Richardson Clover, George W. Tyler, and J. D. Adams, U. S. N.

Triangulation north of Point Conception, Cal.—Assistant W. E. Greenwell, in April, made a reconnaissance along the shore of the Santa Barbara Channel, from Point Mugu to Point Duma, with reference to the stations needed and other requirements for the topographical survey. Before leaving the vicinity, he made a plane-table survey of the vicinity of the town of Hueneme, and determined in position the light-house and the wharf at that point.

In May, the triangulation of the coast of California was resumed by this party at Point Conception, and was pushed northward and westward about seventeen miles. During unfavorable weather in June, Mr. Greenwell prosecuted with success a search for the astronomical station which had been occupied by Assistant Davidson in 1850. The point, after being fully identified, was connected with the triangulation at Cojo Station. Field-work was advanced under many difficulties, alternating between gales of wind and prevailing fogs. Neither roads nor trails having as yet been opened over this line of coast, provisions, forage, etc., were of necessity carried by the hands of the party. The statistics of the triangulation are:

Signals erected	39
Stations occupied	38
Angles measured	188
Number of observations	4,515

Subassistant Eugene Ellicott was attached to this party, and is commended in the field-report for energy in the advancement of the work.

Topography north of Point Sal, coast of California.—Late in February, Assistant L. A. Sengteller proceeded to San Luis Obispo, and in the course of a few days resumed field-work at the point where the operations of his party had closed in the preceding season. The object was to develop the coast by triangulation, and make a subsequent plane-table survey as far south as Point Sal, and there to join with the triangulation executed by Assistant Greenwell in 1867. With every prospect favorable in regard to the work, Assistant Sengteller met with a serious accident on the 11th of March. While passing a narrow deep gulch with the wagon used for transportation, and from which, fearing no danger to himself, he had nevertheless caused his men to alight, the jar in crossing forced one of the reins out of his hand. The frightened team was instantly beyond control. To avoid more imminent peril, in a rough and exceedingly dangerous place, Mr. Sengteller jumped out, and in so doing sustained a comminuted fracture of one of his legs below the knee-joint. On the day following, he was taken to San Luis Obispo, fourteen miles distant, for surgical treatment, and there remained until the 17th of June, when he was able to return to San Francisco.

Mr. Paul Schumacher, who had in previous seasons served temporarily in the party of Assistant Sengteller, was intrusted with the field-operations near San Luis Obispo. Mr. R. J. Currey was detailed to serve as aid. Assistant Sengteller previous to his accident had selected stations and erected signals between Arroyo Grande and Point Sal. Mr. Schumacher joined him for per-

sonal conference at San Luis Obispo on the 23d of March, and under his direction proceeded to occupy the several stations with the theodolite. The party was so occupied until the 20th of May, when the triangulation was fully joined with stations which had been occupied near Point Sal in 1867. Mr. Schumacher then pushed the plane-table survey as far as practicable below San Luis Obispo, and completed a sheet which extends the topography so as to include the Arroyo Grande, below which the coast-line was approximately determined by means of the compass for present purposes. This service was closed on the 5th of June, when the party returned to San Luis Obispo, and were discharged. The statistics of work are as follows:

Signals erected	18
Stations occupied	17
Angles measured	209
Number of observations	4,570

The details of topography comprise an area of rather more than two square miles.

Coast-topography north of Piedras Blancas, Cal.—The detailed plane-table survey in this quarter includes the shore of San Simeon Bay, and at the end of last season had reached Piedras Blancas. For extending the work northward, Assistant Cleveland Rockwell took the field near the close of February at the upper limit of his previous survey. Signals were set up at intervals along the coast, six stations were occupied, and thirty angles were measured with the theodolite by five hundred and ninety-seven observations. From the points so determined, the plane-table survey was advanced northward to a station near which the great unbroken mountain-chain that passes Monterey Bay abuts directly upon the ocean.

The character of topography on the sheet returned by Mr. Rockwell is the usual ragged and bluff coast-line, and beyond it gentle contours back as far as the steep slopes and cañons at the foot of the coast-mountain. At the northern limit, the mountain rises almost immediately from the coast-line, and there the bluff is three hundred feet in perpendicular height. In pushing topographical work farther in the same direction, the party encounters at the outset and must cross the mountain-range, where the elevation is about three thousand feet above the sea-level. Mr. Rockwell closed work on the 25th of April, after completing a plane-table sheet which represents about five miles of coast-line and the roads and surface-features within an aggregate of three and a half square miles. Mr. G. H. Wilson served as aid, and subsequently attended Assistant Rockwell for field-service, to be noticed with work done in Section XI.

Topographical details.—On the coast of California, south of San Francisco Bay, the party of Assistant A. F. Rodgers was engaged during the early part of the present year at several localities. The coast-line, as shown on nine plane-table sheets, was revised by adding the wharves and other structures now existing between San Francisco and Monterey. The coast-lights at Pigeon Point and Santa Cruz were determined in position. Two others, the Two Brothers light-house and the light-house at Mare Island, were connected with the triangulation of San Pablo Bay. After forwarding the results of this work to the office, Mr. Rodgers transferred his party to a station northward of Noyo River, where he is now engaged in advancing the coast-triangulation.

Hydrography of San Francisco Bar and Entrance, Cal.—The party of Assistant Gershom Bradford closed the season on the 2d of December, 1873, having at that date completed soundings to the line Point Boneta and Point Lobos, and also as far as the line joining Lime Point and Fort Point. Soundings were also made inside of the harbor, in the space included between Fort Point, Black Point, Alcatraz Island, south shore of Angel Island, western mouth of Raccoon Straits, and Lime Point. This work was in continuation of a survey of the harbor which had been prosecuted at the outset with the boats of the schooner Marcy. A small tug, however, was chartered for the purpose, and served much better where the strength of the current made it difficult to record soundings in the boats.

At the bar, the soundings were made to define the 10-fathom curve, and from Frank's Lagoon on the north the work was extended southward to a point two miles below the Ocean Side House. Specimens of the bottom were taken at short intervals on the bar. By reference to the self-registering tide-gauge at Fort Point, the soundings were ultimately reduced, after applying a correction for the march of the tide between the bar and that station. In order to find the needful correc-

tion, Assistant Bradford made observations at three temporary tidal stations, two of them near the north end of the bar, and the third near the south end. From a comparison between these observations and those made at other temporary stations cotidal lines were drawn, showing the correction requisite in referring the soundings at all parts of the bar to the bench-mark of the Fort Point tide-gauge.

Comparison of the soundings made by Assistant Bradford with the survey of 1855 shows that the water has deepened about the 4-fathom bank, and that the depth has increased by as much as three feet at a spot off the western end of the bank, where there was formerly a depth of less than four fathoms. Across the bar, the last survey develops a course having nowhere less than thirty-four feet.

In March, Mr. Bradford made careful search for sunken rocks off Fort Point, and found and located in position two, which have been marked as dangers in navigation.

Close examination in the harbor south of Bird Rock developed a shoal spot having only four fathoms of water on it.

For prosecuting the hydrography, the party of Assistant Bradford erected seven signals, and occupied twenty-three stations along the shores. The currents at the surface and below the surface were carefully determined and recorded within the limits of the survey. The general statistics of the work are:

Miles run in sounding	788
Angles measured	8,125
Number of soundings	18,794

Assistant Bradford was efficiently aided in this work by Mr. F. Westdahl.

The special interest which attaches to means and expedients known as "aids to navigation" is well illustrated in the following table, which was compiled by Assistant Davidson to show the arrivals and departures of deep-draught vessels in the care of pilots into or out of the port of San Francisco. Many of the vessels did not take a pilot out, and are therefore not in the table; and some large vessels entered and left without a pilot. The British iron-clad Zealous, drawing 26½ feet of water, crossed the bar twice without a pilot, and both entered and left by the Boneta Channel frequently by merely following the directions given in the Coast Survey Directory. Under each of six years in the following table is given the number of deep-draught vessels *piloted* in or out of San Francisco:

Draught, in feet.	1868.	1869.	1870.	1871.	1872.	1873.	Total.
21	21	55	34	38	66	50	264
21½	5	12	14	16	27	54	128
22	8	10	9	9	15	30	81
22½	2	6	6	5	6	21	46
23	7	9	2	4	12	17	51
23½	1	4	......	......	4	5	14
24	......	4	3	1	......	3	11
24½	......	1	......	1	2	3	7
25	......	......	......	1	3	2	6
26	......	......	......	......	......	1	1

Tidal observations.—The self-registering tide-gauge at Fort Point, Cal., has continued the important series of observations near San Francisco, as heretofore, under the supervision of Col. G. H. Mendell, United States Engineers. The observer, Mr. E. Gray, has tabulated the high and low waters of the year and hourly readings from the registers, in accordance with directions from the tidal division of the office, in which the returns from all the permanent stations are inspected monthly.

Triangulation.—Associated with General Alexander and Colonel Mendell, as a member of the board of commissioners appointed by the President of the United States to devise means for irrigation in several of the valleys of California, Assistant George Davidson was engaged during the win-

ter on the joint report, which has since been printed and issued from the War Department. Meanwhile, under the direction of Mr. Davidson, his own field-party, in charge of Subassistant O. H. Tittmann, advanced the primary triangulation between the Santa Barbara Islands and Monterey Bay, for which reconnaissance had been completed in the preceding season. Mr. Tittmann completed observations with the theodolite at stations on San Miguel and Santa Cruz Islands, and then transferred the party to Santa Barbara station. The winter was exceptionally unfavorable in this region. Latitude and azimuth were determined at each station. Before completing at Santa Barbara, Mr. Tittmann was called to Washington, where Assistant Davidson was completing arrangements needful for observing the transit of Venus at a station in Japan. Subassistant William Eimbeck finished the work at Santa Barbara, and discharged the triangulation-party at the end of April. Messrs. T. J. Lowry, W. S. Edwards, and T. P. Woodward served as aids during the winter. An aggregate of thirty-one hundred and eighty-two measurements for horizontal and vertical angles were recorded at the three main stations. For latitude, three hundred and forty-one observations were made on about sixty stars at San Miguel and Santa Cruz. Azimuth was determined by three hundred and fifty-five observations on Polaris. The records of the work have been duplicated, as usual.

In March, Assistant Davidson occupied stations at San Luis Obispo and San Simeon, and observed for latitude and azimuth at both points. After completing that duty, he reported at Washington, and made preparation for the service in which he is now engaged in Japan.

In the course of the winter, Subassistant Eimbeck and Mr. T. J. Lowry, aid, computed results from observations which had been made in the geographical reconnaissance of the coast of Lower California. Under direction from Assistant Davidson, they left Santa Barbara in May for the region of the Sierra Nevada, and are there engaged in reconnaissance for stations to connect with the primary triangulation at Mount Diablo and Helena.

A field-catalogue of nine hundred and eighty-three transit-stars, furnished by Mr. Davidson has been published. He has presented also, for the archives, tables of fifty-seven thousand star-factors for the reduction of transit-observations. The numerical factors being carried to three places of decimals, these tables, which will be published as soon as practicable, are the most extensive and complete of their kind. At the request of the city authorities, and in association with General Alexander and Admiral John Rodgers, Mr. Davidson acted, before his departure for Asia, as a member of the commission for determining harbor-lines at San Francisco. As far also as his other employments would allow, he has gathered additional material for the Coast Pilots of California, Oregon, Washington Territory, and Alaska.

Rock off the Middle Farallon.—Among the hydrographic notes recorded by Assistant Davidson was mentioned that several years ago the water had been seen to break at a spot off the Middle Farallon, but because seldom seen the existence of the break has frequently been doubted. In order to determine the matter finally, examination was made near the end of June by Assistant Bradford, with a steam-tug chartered for the purpose. The south approach within an area of about one square mile, on being developed by close soundings, revealed the existence of a rock having only five and a half fathoms at mean low water, in a position about half a mile southward and westward of the Middle Farallon. The water deepens rapidly from the shoal point of the rock, eight fathoms being found immediately to the northward and ten fathoms to southward of it. For identifying it in position, bearings were published in July in the usual form of notice to mariners.

In returning to port from the Farallones, Assistant Bradford made some casts with the dredge on San Francisco Bar, and brought up specimens of living *Echini* in the shoal water to the southward of the main channel. Living specimens were brought up at several positions last year when soundings were in progress on that bar.

Triangulation and topography south of Shelter Cove, Cal.—When the last annual report closed, Assistant A. F. Rodgers was yet in the field, and engaged in extending triangulation along the rugged coast south of Shelter Cove. The following are statistics of the work done in the course of two months immediately preceding the middle of December last:

Signals erected	8
Stations occupied	36
Angles measured	260
Number of observations	9,444

While the aid of the party, Mr. E. F. Dickins, prosecuted the triangulation, Mr. Rodgers engaged in plane-table work, and completed three sheets representing a stretch of coast more than usually rugged and difficult of access. The fringe of topography was limited to a width of about half a mile inside of the water-line. In general statistics the sheets represent:

Miles of shore-line	21
Area of topography (square miles)	12

Assistant Rodgers returned to San Francisco on the 20th of December, 1873, and was engaged during the winter in office-work. When the country-roads were again passable, he occupied points at Bodega Head, Tomales Bay, Point Reyes, and Table Mountain, and carefully determined the position of Point Reyes light-house. His party is yet in the field near Noyo River Entrance.

Hydrography near Cresent City, Cal.—At this date, the party of Lieutenant-Commander H. C. Taylor, U. S. N., assistant in the Coast Survey, is engaged with the steamer Hassler on the Pacific coast, near Cresent City. As this report was closed early in July, further notice of the work done near Cresent City will be reserved until next year.

Coast-topography southward of False Klamath.—When this report closes, Assistant A. W. Chase, with his topographical party, is at work on the Pacific coast, in the vicinity of Klamath River. Detailed notice of the progress made in the survey in that quarter will be given in my report for next year.

SECTION XI.

COAST OF OREGON, AND OF WASHINGTON TERRITORY, INCLUDING THE INTERIOR BAYS, PORTS, AND RIVERS.—(SKETCHES NOS. 19 AND 20.)

Hydrography.—As stated in the preceding chapter, part of the season suitable for hydrographic work in the section will be occupied by Lieutenant-Commander Taylor for prosecuting the coast-hydrography near Port Orford, and in running lines of soundings from the coast-line outward to the depth of 500 fathoms. The resulting records have not yet come to hand, and cannot be expected in time to admit of presenting the results in this report.

Survey of the Pacific coast south of Columbia River Entrance.—At this date, the party of Sub-assistant J. J. Gilbert is engaged on the coast of Oregon, in the vicinity of Tillamook Head. The statement of field-work will be received at the close of the season for operations in that quarter, and the progress made by the party will be noticed in detail in my next annual report.

Survey of the Columbia River, Oregon.—When this report closes, Assistant C. Rockwell is at work with his party in advancing the survey of the shores of the Columbia River, above Puget Island. The details and statistics of the survey will be included in my report of next year. Assistant Rockwell is aided in the field by Mr. G. H. Wilson.

Tidal observations.—Under the supervision of Col. G. H. Mendell, United States Engineers, the tide-gauge at Astoria, Oregon, has been kept in operation by Mr. L. Wilson. The observer has continued also the series of meteorological observations, and tabulated the readings of high and low water from the graphical registers of the tide-gauge.

Mr. L. Nessel remains in charge of the self-registering gauge at Port Townshend, W. T. The records forwarded regularly by Colonel Mendell are inspected monthly at the office in Washington. They are in all respects evidence of the conscientious care of the officer to whom the Survey has been under obligations for his supervision of the permanent stations on the Western coast.

Hydrography of Budd's Inlet, W. T.—In a previous season, the south end of this inlet was developed by soundings in the vicinity of Olympia. Having, in the interval, made a continuous survey of the shores, Assistant J. S. Lawson, with his party, in the brig Fauntleroy, took up the hydrography of the main body of the inlet early in April. Signals were reset; all excepting two of those erected for the field-work having gone down in the winter gales, which carried away also the pile that sustained the tide-gauge. At the new tidal station, in addition to observations for

high and low water, consecutive hourly readings of the staff were recorded during fifteen days in May, for comparison with the tidal records of Port Townshend. The arm of the inlet south of Olympia, although bare at low tides, is used by small steamers and sailing-vessels for carrying grain, flour, etc., to and from the mills at Tumwater. This channel will, therefore, be represented by soundings, plotted to show the depths at high water.

After sounding the main body and arm of the inlet as far as Tumwater, Mr. Lawson ran lines of soundings across Dana's Passage, to show the character of the northern approaches to Budd's Inlet. The hydrography completed at the end of May is comprised in the following statistics:

Miles run in sounding	128
Sextant-angles	556
Number of soundings	9,932

Mr. F. A. Lawson served as aid in the hydrographic work. The party is at present engaged on the shores of Duwamish Bay.

SECTION XII.

COAST OF ALASKA TERRITORY.—(SKETCH No. 21.)

Reconnaissance.—Assistant W. H. Dall, with his party, in the schooner Yukon, sailed from San Francisco on the 18th of April, and reached Sitka after a rough and stormy passage of thirteen days. Fortunately, two days of continued clear weather after the arrival gave opportunity for rating the chronometers, and the same opportunity was taken for determining azimuth at the astronomical station which was occupied by Assistant Davidson in 1867 and 1869. On the voyage to Sitka, the currents were noted, and the temperatures of the water at and below the surface were recorded daily on board of the Yukon. At the last date received from Mr. Dall, the prospects were favorable for good progress in the development of the coast by the survey of harbors, the determination of geographical positions, magnetic observations, and such other information as may add to the facilities for navigation in that section of the Pacific. Mr. Dall is provided with a cheap form of apparatus, of his own device, for deep-sea soundings, and, under favorable circumstances, expects results of interest from the deep waters and fishing-banks in the vicinity of the Peninsula of Alaska. He is assisted, as heretofore, by Mr. Marcus Baker.

The party in the Yukon will reach San Francisco probably in October; but this report is of necessity closed in advance of any detailed statement that could be received in time to appear with the results of the present year.

COAST SURVEY OFFICE.

Executive details pertaining to the office branches into which pass the records of triangulation, of observations for latitude, longitude, azimuth, magnetic elements, and of the tides, the topographical and hydrographic sheets, and, in general, the results of all the operations afield and afloat, remain, as heretofore, in charge of Assistant J. E. Hilgard. Under his able direction, the manuscript records and maps, and the original charts plotted from records of soundings, as brought in year by year, take form for publication, after due treatment or discussion in the several office-divisions to which they are referred, and from which the results, when complete, are accepted by the assistant in charge of the office.

To the watchful care and solicitude of Professor Hilgard for the interests of the public service, and his intimate relations with leading scientific men at home and abroad, is mainly due the present standing of the office as a repository of data and as a source yielding information of peculiar value. In recent years, the calls for information met at the office have included a wide range in questions involving either physical research and geographical development or ultimate refinements in scientific processes.

As a member of the International Commission on Weights and Measures, to which body he has been accredited by the President of the United States, Mr. Hilgard, being vice-president of the commission, will take passage for Europe before the close of the present month to attend a meeting of the body at Paris in October. The object sought is the establishment, for at least such pur-

poses as require the utmost precision, of a standard of length acceptable and to be recognized by all enlightened nations, and the construction of identical copies for the use of the several nations represented in the commission. It is evident that such copies, possessing all attainable precision, besides their importance in general scientific uses, are especially so in geodesy, as measurements for geographical purposes in different countries become strictly comparable only by their reference to a common unit of length.

In routine details pertaining to the office, Mr. Hilgard has had the effective co-operation of Assistant F. W. Dorr. The accountability of all persons in employ under the immediate direction of the Assistant in Charge is maintained by monthly reports from each of the office-divisions, in which are noted the daily occupation and kind of work performed by each person.

The following are abstracts from the monthly reports of the year:

Computing Division.—The work of this division has been continued in charge of Assistant Charles A. Schott, with the same general organization as in preceding years, and its condition clearly proves his ability and efficiency in its management. Besides directing, examining, and reporting the work accomplished, and responding to various calls for information, referred to him, Assistant Schott has given personal attention to a computation, for the State of California, of the geodetic records of a line between the Colorado River and Lake Tahoe, forming part of the boundary between Nevada and California; brought to a close the extensive computation connected with the discussion of the secular change of the magnetic declination in North and Central America; presented the hypsometric results of Assistant Cutts's levels in New Jersey in 1870, 1871, and 1873; prepared the annual astronomical, geodetic, and magnetic statistics; made the usual annual determination of the magnetic declination, dip, and intensity at Washington, D. C.; and presented a paper on weights to be given to transit-observations registered chronographically.

The regular computers employed in this division, and the nature of their work in general terms, are as follows:

Assistant T. W. Werner was engaged in computing the plain triangulations; Dr. G. Rumpf, in the comparison of field and office computations, of geodetic work, and the bringing-up of old triangulation, also the supply of field-parties with the requisite data for their work; Mr. E. Courtenay attended to the least-square adjustment of recent triangulations and of magnetic computations; Mr. J. Main revised astronomical and magnetic computations; and Mr. M. H. Doolittle was occupied with miscellaneous computations. Mr. H. H. Gerdes performed the clerical duties of the division.

Professor R. Keith and Mr. F. Hudson have been employed temporarily as computers; the former on astronomical longitudes and the latter on astronomical latitudes.

Tidal Division.—The consideration and revision of all tidal and meteorological observations turned into the office, the correspondence with the observers, supervision of the computations and other work relating to tides and tide-gauges, have been kept up by Mr. R. S. Avery, who has been assisted in the calculations and copying by Messrs. J. Downes, A. Gottheil, L. P. Shidy, J. Würdemann, and M. Thomas.

The primary reductions of observations, and the reductions therefrom of the general results used for charts and other purposes, have been made as soon as practicable after their receipt from the observers in the field; and these results, as well as such other information as was required by observers, or by field-parties, or for office use, have been promptly furnished.

Some improvements applied within the year to the working-apparatus of the tide-gauges have tended to make the data furnished by the observers more complete, and have thus considerably facilitated the office-work.

The tide-tables or predictions for 1875, the ninth year of the series, have been computed in this division, and are published. They contain the approximate predicted times and heights of the tides for about twenty of our most important ports, with tables of constants for finding from them the tides at a large number of intermediate places. These tables show an improvement in accuracy from year to year as the new material accumulates, and admits of thorough discussion.

Hydrographic Division.—The office-work of this division has been performed by Mr. E. Willenbücher, the principal hydrographic draughtsman, assisted by Messrs. J. Sprandel and W. C. Wil-

lenbücher. Numerous projections for field-parties and many tracings of hydrographic sheets have been made, as well as thorough verification of all original sheets and reductions. The new charts have been supplied with sailing-directions; and Mr. E. Willenbücher has also been employed in verifying the sailing-directions, courses, bearings, and distances in the Coast Pilot, the first volume of which is now going through the press.

Drawing Division.—The direction of this division has remained the same as during the previous year. Mr. W. T. Bright has had charge of the details. A steady increase has been made during the year in the production of preliminary charts by the photolithographic process, as will be seen by reference to Appendix No. 4. This mode of issuing charts has thus far given general satisfaction, as it has enabled the office to furnish to the public the results of the field-work without the unavoidable delay involved in engraving.

The number of employés attached to this division, and the character of work performed by each, has been as follows: Mr. A. Lindenkohl continued the drawing of the more elaborate charts; Messrs. H. Lindenkohl and L. Karcher have been engaged upon harbor-charts, photolithographic charts and sketches, field-projections, copper-plate engraving, and lithographic work; Mr. P. Erichsen has filled in topographical details upon the $\frac{1}{80000}$ photographed outline of plane-table sheets as a guide to the engravers, and made diagrams and tracings; Mr. F. Fairfax made projections, tracings, and miscellaneous drawings; Messrs. M. M. Angles and W. Fairfax were engaged upon photolithographic charts, projects, and other miscellaneous duties; Mr. F. Smith copied original field-surveys for reduction by photography, and was engaged upon projects until September 1, when he left the service; Mr. R. F. Bartle was employed on miscellaneous duty until December 1, 1873, and then transferred back to the Engraving Division; Mr. F. Hortig worked upon photolithographic maps and tracings until March 31, when he was discharged; Mrs. M. E. Nesbitt continued during part of the year engaged in copying and duplicating records of the geographical positions of the various sections of the coast; Mr. C. Meuth joined the office in January, and has been engaged in compiling charts to show general progress and in making copies of the sketches of field-work; Mr. H. Eichholtz has continued marking corrections and additions to the published charts; Mr. C. E. Lewis performed clerical work until September 1, when his connection with the office ceased.

The following is a brief summary of the work done in the division:

Projects for new charts prepared	26
Tracings made on special calls	92
Projections made for field-surveys	101
Diagrams prepared	6
Projections made on copper for engraved charts	7
Miscellaneous tracings made for field and office use	105
Topographical sheets traced for reduction by photography	9

The information furnished from the office in reply to special calls has been steadily on the increase. A list accompanies each yearly report, and will be found under the head of Appendix No. 3.

Engraving Division.—This division, which has been for some years past under the effective management of Assistant E. Hergesheimer, continues to give abundant evidence of his skill and taste, and the progress of the work has been most satisfactory. In the course of the year, eleven copper-plate charts have been completed, forty-six have received additions, and ten new ones have been begun; three have been engraved on stone, and fourteen new charts have been published by photo-lithography, besides the usual amount of miscellaneous additions to the progress-sketches and other plates not specified in the tabulated report (Appendix No. 5).

During the past year, Messrs. J. Enthoffer, S. Siebert, H. C. Evans, A. Sengteller, W. A. Thompson, A. M. Maedel, and R. F. Bartle have been employed as topographical engravers.

Messrs. J. Knight, E. A. Maedel, F. Courtenay, and A. Petersen have continued as letter-engravers. Sanding has been engraved by Messrs. H. M. Knight and F. W. Benner.

The miscellaneous engraving has been executed by Messrs. J. C. Kondrup, J. E. Thompson, E. H. Sipe, W. H. Davis, and W. H. Knight. Mr. J. J. Young was attached to the division on the 1st

of August, and will continue work with the pantograph. Mr. L. C. Kerr has performed the clerical duties.

The electrotyping and photographing operations have been continued by Mr. A. Zumbrock, assisted by F. Ober. Thirty-eight electrotype copper-plates, ranging in size from 12 to 1,575 square inches of surface, have been made in the course of the year; the greater number being of the largest class. These are about equally divided into *altos*, or relief-plates, taken directly from the engraved plates, and *bassos*, or printing-plates, taken from the *altos*.

Photographic reductions for the use of the Drawing and Engraving Divisions were also prepared as usual, and two hundred and fifty glass tubes were silvered for heliotropes.

Division of Charts and Instruments.—The operations of this division, which includes, besides the safe-keeping of archives and instruments, the printing of maps and the distribution of charts and reports, the work done also in the instrument-shop and the carpenter-shop, have been conducted by Mr. John T. Hoover, with his usual care and promptness. Since July, the additional duty of keeping the accounts of the office, and making disbursements for the Assistant-in-Charge, has also been assigned to him.

The duty of registering and filing for convenient reference the original maps and charts, and records of observations made by the field-parties, and of keeping an account of the same as they are used temporarily in the office, was performed until April by Mr. Arthur Schott, and after that time by Mr. G. A. Stewart.

During the year, the copper-plate printer in the office, Mr. Frank Moore, has rendered 17,943 copies of charts ready for issue.

Mr. H. Nissen has prepared the backed drawing-paper for field and office use, and also satisfactorily performed the miscellaneous duties pertaining to the folding-room.

The map-room has remained under the care of Mr. Thomas McDonnell. An aggregate of 20,460 copies of charts has been issued during the year, and 1,463 copies of Annual Reports of various years have been distributed.

The work in the instrument-shop was done, under the supervision of Mr. John Clark, by J. Foller, W. Jacobi, G. N. Saegmueller, C. F. Würdemann, and E. Eshleman.

The clerical duties of the office of the Assistant-in-Charge have been performed by Mr. V. E. King, who also kept the office accounts until July, aided by Mr. F. Clancy until May, when the latter resigned, and was temporarily replaced by Mr. Hugh Caperton, jr. Mr. R. L. Hawkins has faithfully discharged the duties of principal accountant and book-keeper in the office of the general disbursing-agent, in which the clerical duties have been performed by Messrs. W. A. Herbert and W. C. Flenner.

In the foresight and experience of the disbursing-agent, Samuel Hein, esq., I have had effective co-operation for maintaining economy; all proposed expenditures incident to the operations of the surveying-parties being in advance shown in detail for official approval, carefully scanned, and, in exceptional cases, revised. The services of Assistant W. W. Cooper, in the care of my official correspondence, instructions, and consequent executive details, under my personal direction, are cheerfully recorded, as are also the industry and devotion to the service of his aid, Mr. Clayton Hoover.

Respectfully submitted.

CARLILE P. PATTERSON,
Superintendent of the United States Coast Survey.

HON. B. H. BRISTOW,
Secretary of the Treasury.

APPENDIX.

APPENDIX No. 1.

Distribution of surveying parties upon the Atlantic, Gulf, and Pacific Coasts of the United States during the surveying season of 1873–'74.

Coast sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION I.				
Atlantic coast of Maine, New Hampshire, Massachusetts, and Rhode Island, including seaports, bays, and rivers.	No. 1	Hydrography (in progress).	Commander John A. Howell, U. S. N., assistant; Lieutenants W. H. Jaques, J. W. Hagenman, E. S. Jacob, Richard Rush, and Master C. A. Bradbury, U. S. N., assistants.	Deep-sea soundings between Nova Scotia and Cape Cod, developing depths in the coast approaches through the Gulf of Maine.
	2	Topography and hydrography (in progress).	J. W. Donn, assistant; F. C. Donn and F. H. Parsons, aids.	Topographical survey of the western and north side of Mt. Desert Island, and soundings in the vicinity. (See also Section III.)
	3	Topography (in progress).	W. H. Dennis, assistant; S. N. Ogden, aid.	Detailed survey of the shores of Eggemoggin Reach, coast of Maine. (See also Section V.)
	4	Topography (in progress).	J. N. McClintock, subassistant; W. Frazer and T. A. Harrison, aids.	Topography of islands and ledges east and west of Isle au Haut and Deer Isle, Penobscot Entrance. (See also Section IX.)
	5	Topography (in progress).	A. W. Longfellow, assistant; W. C. Hodgkins, aid.	Plane-table survey of the eastern shore of Penobscot River, including the vicinity of Castine, Me.
	6	Topography (in progress).	Hull Adams, assistant; R. B. Palfrey, aid.	Topography of the east side of the Penobscot, including Bagaduce River. (See also Section IV.)
	7	Topography (in progress).	Joseph Hergesheimer, subassistant.	Detailed survey of the eastern shore of Penobscot River below Bucksport, Me. (See also Section III.)
	8	Hydrography (in progress).	Horace Anderson, assistant; Master Kossuth Niles, U. S. N., assistant; F. H. North, aid.	Hydrography at the head of Penobscot Bay, including the lower part of Penobscot River. (See also Section VII.)
	9	Triangulation (in progress).	F. W. Perkins, subassistant; C. L. Gardner and F. W. Ring, aids.	Determination of the co-efficient of refraction, and of vertical height at Mt. Desert primary station, and Ragged Mountain near Camden, Me. (See also Section VII.)
		Tidal observations (in progress).	J. G. Spaulding	Series of observations continued at North Haven, Penobscot Bay, with self-registering tide-gauge.
	10	Hydrography (in progress).	Acting Master Robert Platt, U. S. N., assistant; J. B. Adamson, aid.	Soundings in the vicinity of Jeffrey's Ledge, Cashe's Ledge, and Jeffrey's Bank; surface and deep-sea temperatures recorded. Discovery and development of a rock in the channel near Star Island, Isles of Shoals. (See also Section III.)
	11	Triangulation (in progress).	Prof. E. T. Quimby	Determination of geographical positions by triangulation in New Hampshire.
		Tidal observations (in progress).	H. Howland	Tidal observations continued with self-registering gauge at Boston navy-yard.
	12	Special observations (in progress).	C. S. Peirce, assistant; W. E. McClintock, aid.	Pendulum observations at a station near North Adams, Mass., and topographical survey to determine differences in the intensity of gravitation.
	13	Hydrography (in progress).	F. D. Granger, subassistant; Lieut. R. D. Hitchcock, U. S. N., assistant; D. C. Hanson, aid.	Hydrography continued to develop the character of changes at the eastern approach to Nantucket Sound. (See also Section VI.)
	14	Coast Pilot (researches in progress).	J. S. Bradford, assistant; John Barker, draughtsman.	Special examination and tests of sailing-courses in Narragansett Bay; including also notes and views for the Atlantic Coast Pilot. (See also Sections II, III, IV, and V.)
	15	Topography and hydrography (in progress).	A. M. Harrison, assistant; W. H. Stearns and Bion Bradbury, aids.	Detailed survey of the shores and hydrography of the navigable part of Taunton River, Mass. (See also Section VI.)

APPENDIX No. 1—Continued.

Coast sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION I—Continued.	16	Shore-line and hydrography (in progress).	H. L. Whiting, assistant; H. Mitchell, assistant.	Special development, including observati tides and currents, to determine the e proposed changes in the contour of Pro Harbor, R. I. (See also Sections II-VII
SECTION II. Atlantic coast and seaports of Connecticut, New York, New Jersey, Pennsylvania, and Delaware, including bays and rivers; and also Lake Champlain.	1	Topography and hydrography (in progress).	H. G. Ogden, assistant; D. B. Wainwright, aid.	Plane-table survey of the shores and sou in Thames River, Conn., above the na tion at New London. (See also Section
	2	Topography (in progress).	R. M. Bache, assistant	Topography of the shores of New Have bor, Conn.
	3	Triangulation (in progress).	J. A. Sullivan, assistant	Positions of light-houses determined at th ern entrance of Long Island Sound. (S Section III.)
	4	Hydrography (in progress).	J. S. Bradford, assistant; John Barker, draughtsman.	Hydrographic development of the channe ward of Plum Island, Long Island Sound also Sections I, III, IV, and V.)
	5	Hydrography (in progress).	H. Mitchell, assistant; F. F. Nes and H. L. Marindin, assistants; J. B. Weir, aid; Master H. O. Handy, U. S. N., assistant; W. B. French, aid.	Special observations on tides and currents waters of New York Harbor; supplem soundings, and development of a shoal Swash channel of New York Bay. (S Sections IV and V.)
	6	Topography and hydrography (in progress).	F. H. Gerdes, assistant; C. P. Dillaway, subassistant; C. A. Ives, aid (part of season); Hugh Caperton, aid (part of season).	Survey of the shores and hydrography c Jefferson, Long Island Sound, N. Y. (S Section VI.)
		Tidal observations (in progress).	R. T. Bassett	Series of tidal observations at Governor's near New York City, continued with sel tering tide-gauge.
	7	Reconnaissance (in progress).	Richard D. Cutts, assistant; J. F. Pratt, aid.	Stations selected for triangulation betwee Island Sound and Lake Champlain. (S Section IX.)
	8	Topography (in progress).	Andrew Braid, subassistant; C. H. Sinclair, aid.	Shore-lines of Lake Champlain traced White Hall north to Crown Point; topo of Crown Point and Ticonderoga, N. Y also Section VI.)
	9	Topography (in progress).	C. T. Iardella, assistant; H. W. Bache, subassistant.	Shore-line survey of Lake Champlain b Crown Point and Shelburne Bay. (S Section IV.)
	10	Hydrography (in progress).	Charles Junken, assistant (part of season); E. H. Wyvill, aid (part of season); G. A. Morrison, aid.	Hydrography of Lake Champlain from hall northward to Shelburne Bay, and opment of shoals in the vicinity of Is motte. (See also Sections VII and IX.)
	11	Astronomical observations (in progress).	George W. Dean, assistant; A. G. Pendleton, aid.	Latitude and azimuth determined at H Crown Point, and Rouse's Point, N. Y. also Section IX.)
	12	Topography and hydrography (in progress).	Charles Hosmer, assistant; J. De Wolf, aid.	Shore-line survey and soundings contin Great South Bay, Long Island, N. Y. (S Section V.)
	13	Magnetic observations (in progress).	T. C. Hilgard	Determination of the magnetic declinatic and horizontal intensity at Ithaca and C N. Y.; at Bethlehem, Pa., and at Cape N. J.
	14	Topography (in progress).	C. M. Bache, assistant; H. M. De Wees, subassistant; J. J. Evans, aid.	Topography of the shores of Barnegat Bay (See also Section III.)
	15	Hydrography (in progress).	W. I. Vinal, subassistant; E. B. Pleasants, aid.	Soundings in the lower part of Barnegat and hydrography of the bar of Little Eg bor, N. J. (See also Sections IV and V.)
	16	Astronomical observations and triangulation (in progress).	Edward Goodfellow, assistant; C. A. Ives, aid.	Latitude and azimuth observations at K and Barnegat, N. J. Positions of light-l determined at Cape May, and also in Del Bay at Maurice River, Mispillion Cree Hereford Inlet.

APPENDIX No. 1—Continued.

Coast sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION III.				
Atlantic coast and bays of Maryland and Virginia, including seaports and rivers.	1	Coast Pilot	J. S. Bradford, assistant; John Barker, draughtsman.	Examination of harbor entrances and sailing-courses in Chesapeake Bay, and compilation of notes and views for the Atlantic Coast Pilot. (See also Sections I, II, IV, and V.)
	2	Topography	Joseph Hergesheimer, subassistant.	Detailed topographical survey of Marbury Point, D. C., including site of the United States Naval Magazine, and supplementary plane-table work on the east side of the Potomac near Washington and Bladensburg. (See also Section I.)
		Magnetic observations.	Charles A. Schott, assistant	Magnetic declination, dip, and horizontal intensity determined at the standard station in Washington City, D. C.
	3	Triangulation	J. A. Sullivan, assistant	Angular measurements on Sugar Loaf Mountain, Md., to connect local triangulation of the Upper Potomac with the primary triangulation. (See also Section II.)
	4	Triangulation (in progress).	A. T. Mosman, assistant; D. S. Wolcott, aid.	Determination of points by primary triangulation near Front Royal, Va. (See also Section VII.)
	5	Reconnaissance (in progress).	S. C. McCorkle, assistant	Selection of stations for primary triangulation in West Virginia. (See also Section VII.)
	6	Topography and hydrography.	J. W. Donn, assistant; F. C. Donn and F. H. Parsons, aids.	Topography of the shores and soundings in James River, Va., between Warwick River entrance and Sandy Point, including the lower part of the Chickahominy. (See also Section I.)
	7	Topography	C. M. Bache, assistant; H. M. De Wees, subassistant.	Detailed survey, including Norfolk, Portsmouth, and Gosport, Va., and shore-line survey of Nansemond River, Va. (See also Section II.)
	8	Hydrography	Acting Master Robert Platt, U. S. N., assistant; J. B. Adamson, aid.	Hydrography of the Nansemond River, Va. (See also Section I.)
	9	Hydrography (in progress).	J. B. Baylor, aid	Development by soundings of the channel between Craney Island and the main land of Virginia. (See also Sections VI and VII.)
		Inspection	H. L. Whiting, assistant	Inspection of plane-table operations in the field. (See also Sections I, II, IV, V, and VI.)
		Tidal observations	W. J. Bodell	Series of observations continued at Old Point Comfort, Va., with self-registering tide-gauge.
SECTION IV.				
Atlantic coast and sounds of North Carolina, including seaports and rivers.	1	Coast Pilot	J. S. Bradford, assistant; John Barker, draughtsman.	Compilation of descriptions, notes, and views for navigating the coast south of Cape Henry, and for passing the Lookout and Frying Pan Shoals. (See also Sections I, II, III, and V.)
	2	Triangulation (in progress).	George A. Fairfield, assistant; B. A. Colonna and W. B. Fairfield, aids.	Triangulation continued in Pamplico Sound, N. C.
	3	Triangulation and hydrography.	R. E. Halter, assistant; C. L. Gardner and C. H. Fitch, aids.	Triangulation and hydrography of Chowan River, at the head of Albemarle Sound, N. C. (See also Section VII.)
	4	Topography	Hull Adams, assistant; R. B. Palfrey, aid.	Topography of the shores of Chowan River, from the entrance upwards to Harrell's Landing. (See also Section I.)
	5	Topography	C. T. Iardella, assistant; H. W. Bache, subassistant.	Detailed survey on the north side of Pamplico Sound, including the shores of Bell's Bay, Swan Quarter Bay and Island, and Juniper Bay. (See also Section II.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION IV—Continued.	6	Hydrography	F. F. Nes, assistant; E. B. Pleasants and W. B. French, aids.	Hydrography of Pamplico Sound, from Pamplico River entrance eastward to the vicinity of Gull Shoal Rock; and soundings completed in Pungo River. (See also Section II.)
		Inspection	H. L. Whiting	Inspection of plane-table work on the shores of Pamplico Sound. (See also Sections I, II, III, V, and VI.)
	7	Hydrography	W. I. Vinal, subassistant; J. J. Evans and W. S. Bond, aids.	Hydrography of Beaufort Bar, N. C., including the approaches, the harbor, North River, and Newport River. (See also Sections II and V.)
SECTION V.				
Atlantic coast and sea-water channels of South Carolina and Georgia, including sounds, harbors, and rivers.	1	Hydrography	W. I. Vinal, subassistant; J. J. Evans and W. S. Bond, aids.	Soundings on the bar of the western channel of Cape Fear River, N. C., and development of changes in the vicinity. (See also Sections II and IV.)
	2	Topography	W. H. Dennis, assistant; S. N. Ogden, aid.	Detailed survey of the vicinity of Cape Romain, S. C., including Romain River and Oyster Bay. (See also Section I.)
	3	Coast Pilot	J. S. Bradford, assistant; John Barker, draughtsman.	Harbors between Winyah Bay and Savannah examined; and sailing directions, notes, and views compiled for the Coast Pilot. (See also Sections I, II, III, and IV.)
	4	Triangulation, topography, and hydrography.	Charles Hosmer, assistant; W. E. McClintock and J. De Wolf, aids.	Shore-line survey and hydrography of Savannah River, Ga., above and below the city. (See also Section II.)
	5	Hydrography	H. L. Marindin, assistant	Special observations on the currents of Savannah River in the vicinity of Tybee Knoll. (See also Section II.)
	6	Astronomical observations.	F. Blake, assistant; Charles Tappan, aid.	Exchange of clock-signals at Savannah for determining longitude at Charlotte Harbor, Cedar Keys, and Atlanta, Ga. (See also Sections VI and VII.)
		Inspection	H. L. Whiting, assistant	Inspection of plane-table operations in this section, north and south of Charleston, S. C. (See also Sections I, II, III, IV, and VI.)
SECTION VI.				
Atlantic and Gulf coast of the Florida peninsula, including reefs and keys; and the seaports and rivers.	1	Hydrography	F. D. Granger, subassistant; C. P. Dillaway, subassistant; D. C. Hanson, aid.	Hydrography of Fernandina Bar and its approaches, and of the Atlantic coast below Saint John's River entrance. (See also Section I.)
	2	Triangulation, topography, and hydrography.	A. M. Harrison, assistant; W. H. Stearns and Bion Bradbury, aids.	Detailed survey of Halifax and Hillsboro' Rivers, including also Mosquito Inlet and the adjacent coast of Florida. (See also Section I.)
	3	Astronomical observations.	Edwin Smith, subassistant; J. B. Baylor, aid.	Longitude determined by exchange of clock-signals from stations at Key West and Punta Rasa, Fla. (See also Sections V and VII.)
	4	Triangulation and topography.	H. G. Ogden, assistant; D. B. Wainwright, aid.	Triangulation and topography advanced on the east side of Tampa Bay, Fla., including Manatee River. (See also Section II.)
	5	Hydrography	Andrew Braid, subassistant; C. A. Ives and C. H. Sinclair, aids.	Hydrography of Tampa Bay, Fla., from the entrance upwards to Mangrove Point, and including also Manatee River. (See also Section II.)
		Inspection	H. L. Whiting, assistant	Inspection of the plane-table operations at Tampa Bay. (See also Sections I to V.)
SECTION VII.				
Gulf coast and the sounds of West Florida, including ports and rivers.	1	Astronomical observations.	Edwin Smith, subassistant; J. B. Baylor, aid.	Longitude determined by exchange of clock-signals from a station at Cedar Keys, Fla. (See also Sections V and VI.)
	2	Astronomical observations and triangulation.	A. T. Mosman, assistant; D. S. Wolcott, aid.	Azimuth determined and triangulation revised at Cedar Keys. Reconnaissance between Cedar Keys and Fernandina. (See also Section III.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION VII—Continued.	3	Triangulation	F. W. Perkins, subassistant; F. W. Ring, aid.	Triangulation extended along the Gulf coast from Cedar Keys to St. Marks. (See also Section I.)
	4	Hydrography	H. Anderson, assistant; F. H. North and G. A. Morrison, aids.	Hydrographic development of a shoal off Point St. George; soundings in the Gulf approaches to West Pass (St. George's Sound, Fla.); and hydrography of St. Vincent's Sound. (See also Section I.)
	5	Astronomical observations.	Edwin Smith, subassistant; J. B. Baylor, aid.	Longitude determined at a station near Atlanta, Ga., by exchange of clock-signals. (See also Sections V and VI.)
	6	Triangulation	C. O. Boutelle, assistant; H. W. Blair and J. B. Boutelle, aids.	Height of Atlanta base-line above sea-level determined, and triangulation extended northward and eastward.
	7	Triangulation	F. P. Webber, assistant; J. H. Christian and Charles Tappan, aids.	Triangulation continued northward and westward from the base-line near Atlanta, Ga.
	8	Reconnaissance	S. C. McCorkle, assistant	Selection of stations east and west of Lookout Mountain in Georgia, Alabama, and Tennessee for determining geographical positions. (See also Section III.)
	9	Reconnaissance (in progress).	R. E. Halter, assistant; C. H. Fitch, aid.	Reconnaissance along the course of the Ohio River for points to be determined in geographical relation. (See also Section IV.)
SECTION VIII.				
Gulf coast and bays of Alabama, and the sounds of Mississippi and Louisiana to Vermilion Bay, including the ports and rivers.	1	Triangulation and hydrography.	C. H. Boyd, assistant; C. H. Van Orden, aid.	Triangulation and hydrography of the Mississippi River from English Turn upward to Carrollton, La.
		Tidal observations	G. Faust	Observations with tide-staff recorded for determining changes in the water-level at New Orleans.
	2	Triangulation (in progress).	C. H. Boyd, assistant; C. H. Van Orden, aid.	Determination of geographical positions by triangulation in Missouri, west of St. Louis.
	3	Reconnaissance (in progress).	Prof. John E. Davies	Reconnaissance for triangulation to determine geographical positions in the southern part of Wisconsin.
SECTION IX.				
Gulf coast of Western Louisiana, and of Texas, including bays and rivers.	1	Triangulation and topography.	J. N. McClintock, subassistant; J. F. Pratt, aid.	Measurement of base-line, triangulation, and shore-line survey of Sabine Pass, Tex. (See also Section I.)
	2	Hydrography	L. B. Wright, subassistant; A. G. Pendleton and E. H. Wyvill, aids.	Hydrography of Pass Cavallo, including the bar, and of San Antonio Bay, Tex. (See also Section II.)
		Tidal observations	M. Kruse	Series of tidal observations continued with self-registering gauge at St. Thomas, West Indies.
SECTION X.				
Coast of California, including the bays, harbors, and rivers.	1	Hydrography	F. Westdahl, aid	Hydrographic development of a sunken rock off Point Loma, near San Diego, Cal.
	2	Topography	A. W. Chase, assistant	Plane-table survey of the coast of Santa Barbara Channel from Newport Slough to Bolsas River, including part of the course of Santa Ana River.
	3	Triangulation and topography.	Stehman Forney, subassistant	Triangulation and topography of Santa Cruz Island, Santa Barbara Channel.
	4	Hydrography	Commander P. C. Johnson, U. S. N., assistant (part of season); Lieut. Comdr. H. C. Taylor, U. S. N., assistant (part of season); Lieuts. George S. Talcott, Frank Courtis, Richardson Clover, George W. Tyler, and J. D. Adams, U. S. N.	Hydrography of Santa Barbara Channel between Santa Rosa and Santa Cruz Island, and lines of off-shore soundings between Point Concepcion and Monterey Bay. (See also Section XI.)
	5	Triangulation and topography.	W. E. Greenwell, assistant; Eugene Ellicott, subassistant.	Detailed survey of the coast from Point Concepcion westward toward Point Arguello, Cal.

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION X—Continued.	6	Topography	L. A. Sengteller, assistant; R. J. Currey, aid.	Extension of the coast topography near Point Sal. (See also Section XI.)
	7	Triangulation and topography.	Cleveland Rockwell, assistant; G. H. Wilson, aid.	Triangulation and plane-table survey of the Pacific coast continued north of Piedras Blancas, and also in the vicinity of San Simeon, Cal. (See also Section XI.)
	8	Topography	A. F. Rodgers, assistant; E. F. Dickins, aid.	Supplementary topographical details including wharves at Monterey Bay and Half Moon Bay; positions of light-houses determined between Santa Cruz and Point Reyes.
	9	Hydrography	Gershom Bradford, assistant; F. Westdahl, aid.	Soundings and current observations on the bar and inside of San Francisco Bay; development of sunken rocks off Fort Point; discovery of a rock near the Middle Farallon.
		Tidal observations	Maj. G. H. Mendell, United States Engineers; E. Gray.	Series of observations continued at the permanent tidal-station at Fort Point, near San Francisco, with self-registering tide-gauge. (See also Section XI.)
	10	Astronomical observations and triangulation (in progress).	George Davidson, assistant; William Eimbeck and O. H. Tittman, subassistants; T. J. Lowry, W. S. Edwards, and T. P. Woodward, aids.	Triangulation continued and latitude and azimuth observed at primary stations between Santa Barbara and Monterey Bay, including points between Mount Diablo and Helena.
	11	Hydrography (in progress).	Lieut. Comdr. H. C. Taylor, U. S. N., assistant; Lieuts. George S. Talcott, Frank Courtis, Richardson Clover, George W. Tyler, and J. D. Adams, U. S. N., assistants.	Inshore hydrography between Point Reyes and Cape Mendocino, and off-shore soundings between that cape and Crescent City, Cal. Discovery and development of a dangerous rock between Crescent City Harbor and False Klamath. (See also Section XI.)
	12	Topography (in progress).	A. F. Rodgers, assistant; E. F. Dickins, aid.	Coast topography extended in the vicinity of Noyo River entrance, Cal. Measurement of base for continuing the plane-table work northward.
	13	Topography (in progress).	A. W. Chase, assistant	Determination of points and plane-table survey of the coast between Rocky Point and Klamath River. Selection of site for a base-line south of Point St. George.
SECTION XI. Coast of Oregon and of Washington Territory, including the interior bays, ports, and rivers.	1	Hydrography (in progress.)	Lieut. Comdr. H. C. Taylor, U. S. N., assistant; Lieuts. George S. Talcott, Frank Courtis, Richardson Clover, George W. Tyler, and J. D. Adams, U. S. N., assistants.	Inshore hydrography and off-shore soundings near Port Orford, and development of a rock in Chetko Cove, Oreg. (See also Section X.)
	2	Triangulation and topography (in progress).	J. J. Gilbert, subassistant	Detailed survey of the coast of Oregon southward from Columbia River entrance toward Tillamook.
	3	Topography and hydrography (in progress).	Cleveland Rockwell, assistant; G. H. Wilson, aid.	Survey of the shores of Columbia River continued, including the hydrographic development of Woody Channel and Cordell Channel. (See also Section X.)
		Tidal observations	Maj. G. H. Mendell, United States Engineers; L. Wilson, and L. Nessel.	Series of tidal-observations continued with self-registering gauges at Astoria, Oreg., and at Port Townshend, W. T. (See also Section X.)
	4	Triangulation, topography, and hydrography.	J. S. Lawson, assistant; F. A. Lawson, aid.	Survey in progress on the shores and soundings in Duwamish Bay, W. T., southward of West Point. Hydrography of Budd's Inlet completed from Tumwater northward to Dana's Passage.
SECTION XII. Coast of Alaska Territory.	1	Astronomical observations, topography, and hydrography (in progress).	W. H. Dall, assistant; Marcus Baker, aid.	Determination of geographical positions and shore-line survey of harbors on the coast of Alaska; observations of the tides and currents; and deep-sea soundings.

APPENDIX No. 2.

Statistics of field and office work of the United States Coast Survey during the year 1873.

Description.	Previous to January 1, 1873.	1873.	Total to December 31, 1873.
RECONNAISSANCE.			
Area in square miles	73, 903	20, 597	94, 500
Parties, number of	57	4	61
BASE-LINES.			
Primary, number of	13	0	13
Secondary, number of	92	2	94
Length in miles (primary)	79	0	79
Length in miles (secondary, including line measures)	204⅓	15¼	219⅓
TRIANGULATION.			
Area in square miles	61, 909	3, 924	65, 833
Horizontal-angle stations occupied	7, 362	397	7, 759
Geographical positions determined	13, 821	678	14, 499
Vertical-angle stations occupied	390	30	420
Elevations determined, number of	821	104	925
Parties, number of	249	28	377
ASTRONOMICAL OPERATIONS.			
Stations occupied for azimuth	118	9	127
Stations occupied for latitude	202	28	230
Stations occupied for longitude	297	20	317
Parties, number of	73	10	83
Magnetical stations occupied, number of	337	21	358
Parties, number of	69	7	76
TOPOGRAPHY.			
Area surveyed in square miles	22, 405	1, 100	23, 505
Length of general coast in miles	5, 386	105	5, 491
Length of shore-line in miles, including rivers, creeks, and ponds	62, 140	3, 441	65, 581
Length of roads in miles	33, 174	1, 617	34, 791
Parties, number of	333	19	352
HYDROGRAPHY.			
Parties, number of	240	20	260
Number of miles run while sounding	256, 505¼	10, 191	266, 696¼
Area sounded in square miles	64, 776	1, 820	66, 596
Miles run additional of outside or deep-sea soundings	39, 238	695	39, 933
Soundings, number of	11, 313, 145	736, 651	12, 049, 796
Soundings in Gulf Stream for temperature	4, 072	....	....
Tidal stations, permanent	176	8	184
Tidal stations, occupied temporarily	1, 387	37	1, 424
Tidal parties, number of	260	28	288
Current-stations occupied	55	....	....
Current parties	3	....	....
Specimens of bottom, number of	9, 698	139	9, 837
RECORDS.			
Triangulation, originals, number of volumes	1, 566	144	1, 710
Astronomical observations, originals, number of volumes	909	83	992
Magnetical observations, originals, number of volumes	298	16	314
Duplicates of the above, number of volumes	2, 010	91	2, 101
Computations, number of volumes	1, 898	125	2, 023
Hydrographical soundings and angles, original, number of volumes	5, 770	310	6, 080
Hydrographical soundings and angles, duplicates, number of volumes	471	54	525
Tidal and current observations, originals, number of volumes	2, 335	99	2, 434
Tidal and current observations, duplicates, number of volumes	1, 784	27	1, 811

APPENDIX No. 2—Continued.

Description.	Previous to January 1, 1873.	1873.	Total to December 31, 1873.
RECORDS—Continued.			
Sheets from self-registering tide-gauges, number of	2, 051	91	2, 142
Tidal reductions, number of volumes	1, 487	40	1, 527
Total number of volumes of records	18, 528	989	19, 517
MAPS AND CHARTS.			
Topographical maps, originals	1, 308	36	1, 344
Hydrographic charts, originals	1, 188	44	1, 232
Reductions from original sheets	724	25	749
Total number of manuscript maps and charts to and including 1873	....	2, 517	2, 517
Number of sketches made in field and office	2, 689	96	2, 785
ENGRAVING AND PRINTING.			
Engraved plates of finished charts, number of	172	12	184
Engraved plates of preliminary charts, sketches, and diagrams for the Coast-Survey Reports, number of.	551	1	552
Electrotype-plates made	1, 007	36	1, 043
Finished charts published	158	10	168
Preliminary charts and hydrographical sketches published	458	5	463
Printed sheets of maps and charts distributed	292, 841	14, 010	306, 851
Printed sheets of maps and charts deposited with sale-agents	104, 562	6, 893	111, 455
LIBRARY.			
Number of volumes	5, 384	178	5, 562
INSTRUMENTS.			
Cost of	$82, 012 89	$9, 405 84	$91, 418 73

APPENDIX No. 3.

Information furnished from the Coast-Survey Office, by tracings from original sheets, etc., in reply to special calls during the year ending October 1, 1874.

Date.		Names.	Information furnished.
1873.			
November	15	F. Ganahl, esq., Los Angeles, Cal	Topographical survey of the Island of Santa Catalina, contiguous to Catalina Harbor, Cal.
	15	Capt. Robert H. Wyman, U. S. N	Copies of charts showing search for Falmouth Shoal, Pacific Ocean.
	19	John C. Sharp, esq., Boston, Mass	Topographical survey of The Glades and vicinity, near Boston, Mass.
	20	United States Light-House Board	Hydrographic survey of channels on both sides of Bulkhead Shoal, Delaware River.
	24	..........do	Hydrography of Pamplico Sound, vicinity of Hatteras Inlet, N. C.
December	4	Prof. C. H. Hitchcock	Geographical positions in New Hampshire.
	11	Lieut. W. B. Weir, acting signal-officer	Positions of life-saving stations from Cape Henry to Cape Hatteras.
	13	General Francis A. Walker	Area of islands in Santa Barbara Channel, Cal.
	18	United States Light-House Board	Topographical survey of Point Fermin, near San Pedro Harbor, Cal.
1874.			
January	5	Hon. David L. Yulee, Florida	Hydrographic information between Cedar Keys and Ship Island, Gulf of Mexico.
	14	W. H. Aspinwall, esq	Hydrographic survey of St. Augustine Harbor, Fla., from the resurvey of 1870.
	16	Joseph Campbell, esq	Topographical survey of Chisholm's Island, S. C.
	17	Col. W. P. Craighill, Corps of Engineers	Hydrographic survey of Pamplico Sound, vicinity of Oregon Inlet, N. C.
	20	Department of Docks, New York	Topographical and hydrographic survey of the northern shore of the East River, from Mott Haven to Bronck's Creek.
	27	O. A. Brown, captain of Virginia State oyster steamer Tredegar.	Hydrographic information of Metomkin Inlet and vicinity, sea-coast of Virginia.
	28	Sanborn, Hoyt & Co., Fernandina, Fla	Bar of Nassau Sound, from the survey of 1871.
February	2	Prof. Alexander C. Twining, New Haven, Conn	Topographical survey adjacent to the Housatonic River, above the town of Stratford, Conn.
	10	Hon. J. H. Rainey, M. C., South Carolina	Topographical survey of the coast of South Carolina from Georgetown to Murphy Island, including the shores of Winyah Bay and North and South Santee Rivers.
	25	Joseph Campbell, esq	Topographical survey of Chisholm's Islands, and topography bordering on Combahee, Bull, and Coosaw Rivers, S. C.
	26	.........do	Hydrographic survey of North Wimbee Creek, S. C.
	27	Phillips, Larkey & Stayton, law firm of Victoria County, Tex.	Topographical survey of the coast of Texas, including Copano, Aransas, and Corpus Christi Bays, from the surveys made in 1860-'61-'62, and 1867.
March	14	Hon. J. H. Wall, M. C., from Florida	Hydrographic survey of Sawpit and Sisters Creeks, forming inside passage between Nassau Sound and St. John's River, Fla.
	17	W. C. Kerr, esq	Topographical survey, vicinity of boundary line between North and South Carolina.
	18	Brown & Le Baron, civil engineers	Chart of Ipswich and Annisquam Harbor, Mass.
	18	Hon. J. H. Wall, M. C., from Florida	Hydrographic survey of inside passage between Cumberland and Nassau Sounds, Fla
	18	Hon. James H. Platt, jr., M. C., from Virginia	Hydrographic survey of Pagan Creek, tributary of James River, Va.
	23	J. W. Hawes	Tidal information of the Hudson River, N. Y.
	23	George W. Blunt	Do.
	25	Hon. Isaac W. Scudder, Jersey City	Comparative hydrographic survey of the Hudson River, from Castle Point to Jersey City Ferry, from the surveys made in 1855 and 1873.
	28	Calvin W. Pool, esq	Shore-line survey of Cape Ann, east of Squam River, Mass.
April	4	Maj. Peter C. Haines, Corps of Engineers, U. S. A	Hydrographic survey of entrance to Savannah River, Ga.
	4	Theo. G. Ellis, surveyor-general, State of Connecticut	Map of Connecticut, with trigonometrical points plotted to a scale of 1-400000.
	13	Justus Roe, esq	Topographical survey of the shores of Great South Bay, vicinity of Fire Island Inlet, N. Y.
May	8	Ordnance Office	Hydrographic survey of Thames River, Conn., above Naval Station.
	8	E. L. Boudinot, esq., attorney at law	Survey of Little Egg Harbor and Inlet, N. J.
	13	Judge Wm. J. Clark, New Berne, N. C	Hydrographic survey of Newport River and Clubfoot Canal, N. C.
	25	E. F. Kittoe, esq	Hydrographic survey of parts of Combahee and Ashepoo Rivers, S. C.
June	3	Senator James L. Alcorn, of Mississippi	Shore-line statistics of the State of Mississippi.

APPENDIX No. 3—Continued.

Date.		Names.	Information furnished.
1874.			
June	9	Massachusetts harbor commissioners	The entire topographical survey of the islands and headlands in Boston Harbor, Mass.
	13	United States Land Office	Topographical survey of Santa Barbara Island and sketches of San Nicolas and San Clemente Islands.
	15	John B. Dezendorf, esq	Hydrographic survey of Elizabeth River, Eastern Branch, and Tanner's Creek, from the resurvey of 1872'-73.
	16	C. A. Abbey, United States revenue-service	Shore-line of Castine Harbor and vicinity, Me.
	18	Lieut. Richard M. Cutts, U. S. N	Hydrographic survey of Man Island Straits, survey of 1864.
	18	do	Topographical survey of Man Island Straits, from survey of 1851 and 1856.
	18	do	Topographical survey of Man Island, from survey of 1851.
	20	George H. Bradbury, esq	Hydrographic survey of Saco Entrance and Biddeford Pool, Me.
July	16	Maj. W. P. Craighill, Corps of Engineers	Hydrographic surveys of Breton's Bay, Md.; Cristfield Harbor, Md.; and bar of western entrance to Cape Fear River, N. C.
	21	United States Light-House Board	Hydrographic survey of Fire Island Inlet, N. Y.
	29	Ordnance Bureau	Hydrographic and topographical survey of Craney Island, near Norfolk, Va.
August	11	General O. M. Poe, Corps of Engineers	Chart of the coast of South Carolina and Georgia, from Hunting Island to Ossabaw Sound, including Savannah River, with triangulation points plotted on.
	17	Ordnance Bureau	Hydrographic survey of Craney Island Cove, Va.
	17	S. T. Abert, United States civil engineer	Hydrographic survey of Elizabeth River and Hampton Creek, Va.
	17	do	Hydrographic survey of Elizabeth River, from Craney Island to Norfolk, Va.
	17	do	Hydrographic survey of Elizabeth River, from Norfolk to Navy Yard, Va.
	17	do	Hydrographic survey of Pagan Creek, James River, Va.
	17	do	Hydrographic survey of Urbana Creek, Va.
	17	do	Topographical survey of part of the Chickahominy River, Va.
	17	do	Hydrographic survey of part of the Chickahominy River, Va.
	17	do	Topographical survey of the Pamunky and Mattapony Rivers, Va.
September	4	Col. V. Stamp	Topographical survey of Baltimore and environs, Md.
	12	Pilot commissioners, New York	Hydrographic survey of Great South Bay, off Inslip, Long Island.
	21	Board of harbor commissioners, Massachusetts	Two projections, scale 1-2400 and 1-1200, covering the water-fronts of Boston, East Boston, and Charlestown.
	26	General Q. A. Gillmore, United States Corps of Engineers	Hydrographic survey of inside passage between Nassau Sound and the St. John's River, by way of Sawpit and Sisters Creeks, Fla.

APPENDIX No. 4.

DRAWING DIVISION.

Charts completed or in progress during the year ending October 1, 1874.

1. Hydrography. 2. Topography. 3. Drawing for photographic reduction. 4. Details on photographic outlines. 5. Verification. 6. Lettering.

Title of charts.	Scale.	Draughtsmen.	Remarks.
COMMENCED.			
Coast chart No. 58, Cumberland Sound, Saint John's River and coast southward.	1-80,000	2. P. Erichsen. 2. F. Fairfax	
Coast chart No. 1, East Quoddy light to Seal Island light	1-80,000	3. F. Smith. 4. P. Erichsen	
Harbor chart, Penobscot River, Me.	1-40,000	1. A. Lindenkohl	
CONTINUED BY ADDITIONS.			
Coast chart No. 3, Petit Manan light to Naskeag Point, Me.	1-80,000	3. F. Smith	
Coast chart No. 4, Naskeag Head to White Head light, Me.	1-80,000	3. F. Smith. 4. H. Lindenkohl. 1. A. Lindenkohl. 4. P. Erichsen. 2. A. Lindenkohl. 3. F. Hortig.	
General coast chart I, Quoddy Head to Cape Cod, Mass	1-400,000	1. A. Lindenkohl	
Harbor chart, Casco Bay, Me	1-40,000	2. P. Erichsen	Topographical details.
Coast chart No. 8, Wells to Cape Ann, Mass	1-80,000	1. A. Lindenkohl	
Harbor chart, Rockport Harbor, Mass	1-20,000	1. A. Lindenkohl	
Coast chart No. 20, New York Bay and Harbor	1-80,000	1. A. Lindenkohl. 1. F. Fairfax	
Harbor chart, New York Harbor (upper sheet)	1-40,000	2. A. and H. Lindenkohl	
Harbor chart, New York Harbor (lower sheet)	1-40,000	1. A. Lindenkohl	
Harbor chart, Lake Champlain, sheet No. 1, from Rouse's Point to Cumberland Head.	1-40,000	2. A. Lindenkohl	
Harbor chart, Lake Champlain, sheet No. 2, from Cumberland Head light to Ligonier Point.	1-40,000	2. A. Lindenkohl	
Coast chart No. 11, Monomoy and Nantucket Shoals, Mass.	1-80,000	1. A. Lindenkohl	
Coast chart No. 13, Narragansett Bay, R. I.	1-80,000	2. A. Lindenkohl. 3. F. Smith. 2. F. Fairfax.	
Coast chart No. 15, Long Island Sound, middle sheet, from Plum Island to Welch's Point.	1-80,000	1. A. Lindenkohl	
Coast chart No. 32, Chesapeake Bay, from York River to Pocomoke Sound.	1-80,000	1. A. Lindenkohl	
Harbor chart, Potomac River, Indian Head to Georgetown, D. C.	1-40,000	2. A. Lindenkohl	
General coast chart No. V, Cape Henry, Va., to Cape Lookout, N. C.	1-400,000	2. A. Lindenkohl	
Coast chart No. 40, Albemarle Sound, eastern sheet, including Currituck, Croatan, and Roanoke Sounds.	1-80,000	1. A. Lindenkohl. 1. L. Karcher	
Coast chart No. 41, Albemarle Sound, western sheet to head of Sound.	1-80,000	2. A. Lindenkohl	
General coast chart No. VII, Cape Romain to Cumberland Sound.	1-400,000	2. A. Lindenkohl. 1. A. Lindenkohl	
Coast chart No. 44, Pamplico and Neuse Rivers, N. C	1-80,000	2. H. Lindenkohl. 2. A. Lindenkohl	
Coast chart No. 54, Long Island to St. Helena Sound, S. C.	1-80,000	1. A. Lindenkohl	
Coast chart No. 55, Hunting Island to Ossabaw Island, Ga.	1-80,000	2. A. Lindenkohl. 2. H. Lindenkohl. 1. A. Lindenkohl.	
Coast chart No. 57, Sapelo light to Fernandina, Fla	1-80,000	2. H. Lindenkohl	
Coast chart No. 94, Mississippi Delta and River	1-80,000	1. L. Karcher	
Harbor chart, St. Mary's River and Fernandina Harbor	1-20,000	1. A. Lindenkohl	
General coast chart No. XIII, Cape San Blas to Mississippi Delta.	1-400,000	1. A. Lindenkohl. 2. A. Lindenkohl	
Coast chart No. 107, Matagorda Bay, Tex	1-80,000	1. A. Lindenkohl	
Sailing chart, Pacific coast No. 2, Santa Barbara Channel	1-200,000	2. A. Lindenkohl	
Do	1-200,000	H. Lindenkohl, engraving on copper	
Sailing chart, Point Pinos to Bodega Head, including San Francisco Bay, Cal.	1-200,000	1 and 2. A. Lindenkohl	
Reconnaissance of the western coast, in three sheets, from San Diego to Cape Flattery.	1-1,200,000	1. A. Lindenkohl	

APPENDIX No. 4—Continued.

Title of charts.	Scale.	Draughtsmen.	Remarks.
COMPLETED.			
Harbor chart, Penobscot Bay, western sheet	1-40, 000	2. A. Lindenkohl	
Harbor chart, Little Egg Harbor, N. J	1-40, 000	1 and 2. A. Lindenkohl. 1 and 2. H. Lindenkohl.	
Harbor chart, Moose-a-bec Bar, Me	1-15, 000	1. A. Lindenkohl	
Sketch, entrance to St. John's River, Fla	1-25, 000	1. H. Lindenkohl	
Do	1-25, 000	H. Lindenkohl, engraved on stone	
Sketch, search for Falmouth Shoal, coast of Cal		A. Lindenkohl	
Harbor chart, Columbia River, Oreg., sheet No. 2	1-40, 000	2. A. Lindenkohl	
Sailing charts, Lower California, from Cape San Lucas to Cerros Island.	1-1, 200, 000	1 and 2. A. and H. Lindenkohl	
Sailing charts, Lower California, from Cerros Island to San Diego.	1-1, 200, 000	1 and 2. A. and H. Lindenkohl	
Sailing charts, Lower California, from Cape San Lucas to Cerros Island.	1-1, 200, 000	H. Lindenkohl, engraved on stone	
Sailing charts, Lower California, from Cerros Island to San Diego.	1-1, 200, 000	H. Lindenkohl, engraved on stone	
PHOTOLITHOGRAPHIC CHARTS COMPLETED.			
Approaches to Dix Island, Me	1-15, 000	1 and 2. M. Angles	
Belfast Bay, Me	1-15, 000	1 and 2. F. Hortig. 1 and 2. M. Angles. 6. C. Mouth.	
Lake Champlain, sheet No. 1, from Rouse's Point to Cumberland Head.	1-50, 000	1. A. Lindenkohl. 1 and 2. H. Lindenkohl.	
Lake Champlain, sheet No. 2, from Cumberland Head to Ligonier Point.	1-50, 000	1. A. Lindenkohl. 1 and 2. H. Lindenkohl.	
Schuylkill River	1-10, 000	1 and 2. F. Fairfax	
St. Andrews and Jekyl Sounds, Ga	1-60, 000	1 and 2. P. Erichsen and M. Angles	
Tortugas Harbor, Fla	1-8, 000	1 and 2. F. Fairfax	
Approaches to Tortugas Harbor, Fla	1-30, 000	1. A. Lindenkohl. 1. H. Lindenkohl. 6. F. Fairfax. 6. F. Hortig.	
Mendocino Bay, Cal	1-15, 000	1 and 2. L. Karcher	
Chetko River, Oreg	1-15, 000	1 and 2. F. Fairfax	
PHOTOLITHOGRAPHIC CHARTS IN PROGRESS.			
Raritan River to city of New Brunswick	1-15, 000		
Androscoggin River to city of Brunswick, Me	1-15, 000		
Kennebec River to town of Gardiner	1-15, 000		
Elizabeth River and branches, Va	1-25, 000	1 and 2. L. Karcher and M. Angles	
Hampton Roads, Va	1-25, 000	1. L. Karcher	
Catalina Harbor, Cal	1-15, 000	2. P. Erichson	
Hunters Cove, Cal	1-15, 000	1 and 2. F. Smith	

APPENDIX No. 5.

ENGRAVING DIVISION.

Plates completed, continued, or commenced during the year ending October 1, 1874.

1. Outlines. 2. Topography. 3. Sanding. 4. Lettering.

Title of plate.	Scale.	Engravers.
COMPLETED.		
General coast chart.		
No. II, from Cape Ann to Gay Head	1-400,000	4. A. Petersen.
Coast charts.		
No. 11, from Monomoy to Muskeget Channel, (new edition)	1-80,000	1 and 2. J. Enthoffer and W. A. Thompson. 3. W. A. Thompson. 4. A. Petersen and E. A. Maedel.
Pamplico River	1-80,000	2 and 3. H. C. Evans. 4. A. Petersen and J. G. Thompson.
Neuse River	1-80,000	2 and 3. H. C. Evans. 4. A. Petersen.
Harbor charts.		
Moose-a-bec Reach	1-40,000	3. H. M. Knight. 4. J. G. Thompson.
St. George's River and Muscle Ridge Channel	1-40,000	2. W. A. Thompson. 3. H. M. Knight. 4. A. Petersen.
Damariscotta and Medomak Rivers	1-40,000	2. W. A. Thompson. 3. H. M. Knight. 4. E. A. Maedel and E. H. Sipe.
New York Bay and Harbor (2 sheets)	1-40,000	2. W. A. Thompson. 4. E. A. Maedel and A. Petersen.
Yaquina River Entrance	1-20,000	1 and 2. R. F. Bartle.
Columbia River, No. 1	1-40,000	2. S. Siebert.
CONTINUED.		
General coast charts.		
No. I, from Quoddy Head to Cape Cod	1-400,000	1 and 2. J. Enthoffer. 3. H. M. Knight. 4. F. Courtenay.
No. V, from Cape Henry to Cape Lookout	1-400,000	1 and 2. A. M. Maedel. 4. E. A. Maedel and A. Petersen.
No. VII, from Cape Romain to Amelia Island	1-400,000	1 and 2. A. M. Maedel. 3. H. M. Knight. 4. E. A. Maedel and A Petersen.
No. XIII, from Cape San Blas to Mississippi Delta	1-400,000	3. H. M. Knight.
Santa Barbara Channel, No. 2	1-200,000	1. W. A. Thompson. 2. H. Lindenkohl. 4. A. Petersen.
Coast charts.		
No. 3, Frenchman's and Blue Hill Bays	1-80,000	1 and 2. J. Enthoffer. 4. E. A. Maedel.
No. 4, Penobscot Bay	1-80,000	1 and 2. J. Enthoffer. 4. E. A. Maedel.
No. 6, Kennebec Entrance to Saco River	1-80,000	2. A. Sengteller. 3. H. M. Knight.
No. 13, Cuttyhunk to Block Island, including Narragansett Bay.	1-80,000	1 and 2. J. Enthoffer and W. A. Thompson. 3. H. M. Knight. 4. J. Knight.
No. 29, Chincoteague Inlet to Hog Island	1-80,000	3. F. W. Benner.
No. 30, Hog Island to Cape Henry	1-80,000	3. W. A. Thompson. 4. J. Knight.
No. 55, Hunting Island to Ossabaw Sound	1-80,000	1 and 2. A. Sengteller. 4. E. A. Maedel.
No. 56, Savannah to Sapelo Island	1-80,000	3. H. M. Knight. 4. E. A. Maedel.
No. 57, Sapelo Island to Amelia Island	1-80,000	1 and 2. A. Sengteller. 3. F. W. Benner. 4. E. A. Maedel.
No. 86, Choctawhatchee Inlet to Pensacola Entrance	1-80,000	3. F. W. Benner. 4. F. Courtenay.
No. 91, Lakes Borgne and Pontchartrain	1-80,000	2. W. A. Thompson. 4. A. Petersen.
No. 94, Mississippi River, No. 1	1-80,000	1 and 2. A. M. Maedel. 3. H. M. Knight. 4. A. Petersen.
No. 107, Matagorda Bay	1-80,000	2. W. A. Thompson.
Harbor charts.		
Penobscot Bay	1-40,000	1. J. C. Kondrup. 4. F. Courtenay.
Plymouth, Kingston, and Duxbury Harbors	1-40,000	2. S. Siebert. 4. J. Knight.
Potomac River, No. 4 (new edition)	1-40,000	1 and 2. J. C. Kondrup and H. M. Knight.
Savannah River and Wassaw Sound	1-40,000	2. E. H. Sipe.
St. Mary's River and Fernandina Harbor (new edition)	1-20,000	1 and 2. J. C. Kondrup. 3. H. M. Knight and W. A. Thompson. 4. A. Petersen and J. G. Thompson.
Doboy and Altamaha Sounds	1-40,000	1 and 2. J. C. Kondrup and A. M. Maedel. 4. E. H. Sipe.
Columbia River, No. 2	1-40,000	3. F. W. Benner. 4. W. H. Davis.
COMMENCED.		
Coast charts.		
No. 58, from Amelia Island southward	1-80,000	1. A. Sengteller.
No. 108, Pass Cavallo and San Antonia Bay	1-80,000	1. J. C. Kondrup.
No. 109, Aransas and Copano Bays	1-80,000	1. H. C. Evans.
Harbor charts.		
Belfast Harbor	1-20,000	1. J. Enthoffer, A. M. Maedel, and W. H. Knight. 4. W. H. Knight.
Penobscot River and Belfast Bay	1-40,000	1. J. J. Young.
New Haven Harbor	1-20,000	1 and 2. R. F. Bartle.
Little Egg Harbor	1-40,000	1 and 2. A. Sengteller, J. C. Kondrup, and E. H. Sipe. 4. E. H. Sipe.
Whale Branch, inside passage between Broad and Coosaw Rivers.	1-40,000	1. J. G. Thompson. 4. W. H. Davis.
St. Andrew's Sound	1-40,000	1, 3, and 4. J. G. Thompson.
Trinidad Harbor	1-15,000	1 and 2. R. F. Bartle. 4. J. G. Thompson and W. H. Davis.

APPENDIX No. 6.

Geographical positions of prominent places in the United States determined astronomically or cally by the United States Coast Survey.

(The position referred to is the Coast Survey Station.)

Locality.		Latitude.	Longitude.* In arc.	Longitude.* In time.
		° ′ ″	° ′ ″	h. m. s.
Calais, Me	Coast-Survey Observatory	45 11 05	67 16 50	4 29 07.3
Eastport, Me	Congregational Church	44 54 15	66 59 14	4 27 56.9
Machias, Me	Town-hall	44 43 01	67 27 21	4 29 49.4
Bangor, Me	Thomas' Hill	44 48 23	68 46 59	4 35 07.9
Belfast, Me	Methodist Church	44 25 29	69 00 19	4 36 01.3
Rockland, Me	Episcopal Church	44 06 06	69 06 52	4 36 27.5
Augusta, Me	Baptist Church	44 18 52	69 46 37	4 39 06.5
Bath, Me	Winter Street Church	43 54 55	69 49 00	4 39 16.0
Brunswick, Me	College spire	43 54 29	69 57 44	4 39 50.9
Portland, Me	Custom-house	43 39 28	70 15 18	4 41 01.2
Portsmouth, N. H	Fort Constitution	43 04 16	70 42 34	4 42 50.3
Newburyport, Mass	Academy	42 48 30	70 52 28	4 43 29.9
Hampton, N. H	Baptist Church	42 56 15	70 50 12	4 43 20.8
Gloucester, Mass	Union Church	42 36 46	70 39 59	4 42 39.9
Salem, Mass	South Church	42 31 10	70 53 58	4 43 35.9
Boston, Mass	State-house	42 21 28	71 03 50	4 44 15.3
†Cambridge, Mass	Harvard College observatory	42 22 52	71 07 43	4 44 30.9
Watertown, Mass	Arsenal	42 21 41	71 09 45	4 44 39.0
Plymouth, Mass	Pier-head	41 58 44	70 39 12	4 42 36.8
Provincetown, Mass	New Union spire	42 03 00	70 11 18	4 40 45.2
Nantucket, Mass	South tow'd church	41 16 55	70 05 57	4 40 23.8
New Bedford, Mass	Baptist Church	41 38 10	70 55 36	4 43 42.4
Providence, R. I	Universalist Church	41 49 26	71 24 19	4 45 37.3
Newport, R. I	Spire	41 29 12	71 18 49	4 45 15.3
New London, Conn	Groton Monument	41 21 16	72 04 47	4 48 19.1
New Haven, Conn	College spire (middle)	41 18 28	72 55 45	4 51 43.0
New York, N. Y	City-hall	40 42 44	74 00 24	4 56 01.6
Do	Rutherfurd's Observatory	40 43 49	73 59 15	4 55 57.0
Do	Trinity spire	40 42 26	74 00 45	4 56 03.0
Do	Navy-yard flag-staff	40 42 02	73 58 51	4 55 55.4
Do	Saint John's Church	40 43 13	74 00 25	4 56 01.7
Brooklyn, N. Y	City-hall	40 41 31	73 59 27	4 55 57.8
Do	Saint Ann's Church	40 41 59	73 59 26	4 55 57.7
Do	Saint Paul's Church	40 42 38	74 00 35	4 56 02.3
Jersey City	Gas-chimney	40 43 28	74 02 24	4 56 09.6
Do	Spire	40 42 50	74 02 17	4 56 09.1
Sandy Hook, N. J	Light-house	40 27 40	74 00 09	4 56 00.6
Newburgh, N. J	Spire	41 30 06	74 00 33	4 56 02.2
Albany, N. Y	Presbyterian Church	42 39 03	73 45 24	4 55 01.6
Troy, N. Y	Dutch Reformed Church	42 43 00	73 42 16	4 54 49.1
Burlington, Vt	College-dome	44 28 52	73 12 09	4 52 48.6
Plattsburgh, N. Y	Brown spire	44 41 57	73 26 54	4 53 47.6
Princeton, N. J	Seminary-cupola	40 20 40	74 39 55	4 58 39.7
Trenton, N. J	Presbyterian Church	40 13 10	74 45 50	4 59 03.3
Philadelphia, Pa	State-house	39 56 53	75 09 03	5 00 36.2
Do	Girard College	39 58 24	75 10 15	5 00 41.0
Do	St. Peter's Church	39 56 33	75 08 55	5 00 35.7
Wilmington, Del	Town-hall	39 44 27	75 33 03	5 02 12.2
Cape May, N. J	Court-house	39 04 53	74 49 29	4 59 17.9
New Castle, Del	Episcopal spire	39 39 36	75 33 48	5 02 15.2
Baltimore, Md	Washington Monument	39 17 48	76 36 59	5 06 27.9

* Depends on latest telegraphic data (counted from Greenwich).

† Astronomical longitude of dome, $4^h\ 44^m\ 30^s.98 \pm 0^s.$

APPENDIX No. 6—Continued.

Locality.		Latitude.	Longitude.	
			Arc.	Time.
		° ′ ″	° ′ ″	h. m. s.
Washington, D. C	Capitol dome	38 53 20	77 00 36	5 08 02.4
Do	*United States Naval Observatory	38 53 39	77 03 08	5 08 12.5
Fredericksburgh, Va	Episcopal Church	38 18 06	77 27 38	5 09 50.5
Richmond, Va	Capitol	37 32 16	77 26 04	5 09 44.3
Petersburgh, Va	Court-house	37 13 47	77 24 16	5 09 37.1
Norfolk, Va	City-hall	36 50 47	76 17 22	5 05 09.5
Elizabeth City, N. C	Court-house	36 17 58	76 13 23	5 04 53.5
New Berne, N. C	Episcopal spire	35 06 21	77 02 24	5 08 09.6
Edenton, N. C	Court-house	36 03 24	76 36 31	5 06 26.1
Beaufort, N. C	......do	34 43 05	76 39 48	5 06 39.2
Smithville, N. C	Geodetic station	33 54 58	78 01 08	5 12 04.5
Georgetown, S. C	Episcopal Church	33 22 08	79 16 49	5 17 07.3
Charleston, S. C	St. Michael's Church	32 46 34	79 55 49	5 19 43.3
Do	Gibbes' Observatory	32 47 07	79 56 11	5 19 44.7
Beaufort, S. C	Episcopal Church	32 26 02	80 40 27	5 22 41.8
Savannah, Ga	Exchange spire	32 04 52	81 05 26	5 24 21.7
Darien, Ga	Winnowing House	31 21 54	81 25 39	5 25 42.6
Brunswick, Ga	Academy	31 08 51	81 29 26	5 25 57.7
Fernandina, Fla	Astronomical station	30 40 18	81 27 47	5 25 51.1
Jacksonville, Fla	Methodist Church	30 19 43	81 39 14	5 26 36.9
St. Augustine, Fla	Presbyterian Church	29 53 20	81 18 41	5 25 14.7
St. Mary's, Ga	Market-house	30 43 12	81 32 53	5 26 11.5
Key West, Fla	Tifft's Observatory	24 33 31	81 48 31	5 27 14.1
Cedar Keys, Fla	Depot Key (astronomical station)	29 07 30	83 02 45	5 32 11.0
St. Marks, Fla	Fort Saint Marks	30 09 01	84 12 30	5 36 50.0
Apalachicola, Fla	Flag-staff	29 43 30	84 59 00	5 39 56.0
Pensacola, Fla	Flag-staff (public square)	30 24 33	87 12 53	5 48 51.5
Do	Navy-yard chimney	30 20 49	87 16 06	5 49 04.4
Warrington, Fla	Flag-staff	30 20 50	87 16 35	5 49 06.3
Mobile, Ala	Episcopal Church	30 41 26	88 02 28	5 52 09.9
East Pascagoula, Miss	Astronomical station	30 20 42	88 32 45	5 54 11.0
Mississippi City, Miss	Geodetic station	30 22 54	89 01 57	5 56 07.8
New Orleans, La	United States Mint	29 57 46	90 03 28	6 00 13.9
Do	Cathedral	29 57 34	90 03 49	6 00 15.3
Galveston, Tex	Cathedral (north spire)	29 18 17	94 47 26	6 19 09.7
Indianola, Tex	Geodetic station	28 32 28	96 31 01	6 26 04.0
Matagorda, Tex	......do	28 41 29	95 57 56	6 23 51.7
Lavaca, Tex	Astronomical station	28 37 36	96 37 21	6 26 29.4
San Diego, Cal	Telegraph and astronomical station	32 43 06	117 09 40	7 48 38.7
Los Angeles, Cal	Court-house	34 03 05	118 14 32	7 52 58.1
Santa Barbara, Cal	Mission Church (north tower)	34 26 10	119 42 42	7 58 50.8
San Buenaventura, Cal	Geodetic station	34 15 46	119 15 56	7 57 03.7
Santa Clara, Cal	Catholic Church	37 20 49	121 56 26	8 07 45.7
Monterey, Cal	Azimuth station	36 35 21	121 52 59	8 07 31.9
San José, Cal	Spire	37 19 58	121 53 39	8 07 34.6
Santa Cruz, Cal	Warehouse flag-staff	36 57 31	122 01 29	8 08 05.9
San Francisco, Cal	Presidio triangulation station	37 47 30	122 27 49	8 09 51.3
Do	Washington Square Astro'l Observ'y	37 47 55	122 24 32	8 09 38.1
Benicia, Cal	Church	38 03 05	122 09 23	8 08 37.5
Eureka, Cal	Methodist Church	40 48 11	124 09 41	8 16 38.7
Crescent City, Cal	Astronomical Station Battery	41 44 43	124 12 16	8 16 49.1
Astoria, Oreg	Flag-staff	46 11 19	123 49 42	8 15 18.8
Kalama, Wash	Methodist Church	46 00 26	122 50 39	8 11 22.6
Seattle, Wash	Astronomical station	47 35 54	122 19 59	8 09 19.9
Port Townsend, Wash	......do	48 06 56	122 44 58	8 10 59.9
Steilacoom, Wash	Methodist Church	47 10 20	122 35 51	8 10 23.4

* Astronomical longitude of dome, $5^h\ 08^m\ 12^s.09 \pm 0^s.06$.

APPENDIX No. 6—Continued.

INTERIOR STATIONS.

ASTRONOMICAL STATIONS.

Locality.		Latitude.	Longitude.	
			In arc.	In time.
		° ′ ″	° ′ ″	h. m. s.
Omaha, Nebr	Presbyterian Church	41 15 43	95 56 14	6 23 44.9
Columbus, Ohio	Capitol	39 57 40	82 59 40	5 31 58.7
Oakland, Ky		37 02 28	86 15 19	5 45 01.2
Chetopa, Kans		37 02 13	95 06 08	6 20 24.5
Shelbyville, Ky		38 12 45	85 13 15	5 40 53.0
Cleveland, Ohio	Marine Hospital	41 30 25	81 41 30	5 26 46.0
Cedar Falls, Iowa		42 32 32	92 26 42	6 09 46.8
Sherman, Wyo		41 07 50	105 23 33	7 01 34.2
Verdi, Nev		39 31 05	119 57 45	7 59 51.0
St. Louis, Mo	Washington University	38 38 03	90 12 14	6 00 49.0
Denver, Colo	School-house spire	39 45 00	104 59 33	6 59 58.2
Colorado Springs, Colo	Experimental garden	38 50 00	104 49 08	6 59 16.5
Trinidad, Colo	Methodist Church	37 10 14	104 30 08	6 58 00.5
La Crosse, Wis	Court-house square	43 48 50	91 14 48	6 04 59.2
Madison, Wis	University grounds	43 04 33	89 24 03	5 57 36.2
Minneapolis, Minn	State University grounds	44 58 38	93 14 08	6 12 56.5
Carpenter's Point, N. Y		41 21 23	74 41 39	4 58 46.6
Allegheny Observatory, Pa		40 27 36	80 00 44	5 20 02.9
Salt Lake City, Utah	Temple Square observatory	40 46 04	111 53 47	7 27 35.1
Springfield, Ill	Near new State-house	39 47 57	89 39 20	5 58 37.3
Des Moines, Iowa	Near court-house	41 35 03	93 37 16	6 14 29.1
Mattoon, Ill		39 29 10	88 23 08	5 53 32.5
Burlington, Iowa	South hill, public square	40 48 22	91 06 25	6 04 25.7
Hudson, Ohio	Western Reserve College	41 14 43	81 26 03	5 25 44.2
Falmouth, Ky		38 40 37	84 17 20	5 37 09.3
Cincinnati, Ohio	Mitchell's Observatory (old)	39 05 54	84 29 45	5 37 59.0
Wilmington, N. C	Episcopal church	34 14 02	77 56 38	5 11 46.5
Raleigh, N. C		.. .. ..	78 38 05	5 14 32.3
Columbia, S. C		33 59 58	81 02 03	5 24 08.2
Macon, Ga		32 50 25	83 37 36	5 34 30.4
Atlanta, Ga	City-hall	33 44 57	84 23 22	5 37 33.5
Eufaula, Ala		31 53 41	85 08 21	5 40 33.4
Montgomery, Ala		32 22 45	86 18 00	5 45 12.0
Lower Peach Tree, Ala		31 50 21	87 32 41	5 50 10.7
Julesburg, Colo		40 59 02	102 21 22	6 49 25.4
Bushnell, Nebr		41 13 54	103 52 57	6 55 31.8
Florence, Ala		34 47 13	87 41 40	5 50 46.7
Chickasaw, Miss	Near Eastport	34 53 30	88 06 25	5 52 25.7
Clifton, Tenn		35 23 17	88 01 05	5 52 04.3
Johnsonville, Tenn		36 03 50	87 59 41	5 51 58.7
Fort Henry, Tenn		36 30 22	88 03 40	5 52 14.7
Patterson's Landing, Ky		37 03 12	88 25 12	5 53 40.8
Paducah, Ky		37 04 36	88 36 48	5 54 27.2
Mound City, Ill		37 04 47	.. .. ..	.. ..
Cairo, Ill		36 59 48	89 11 14	5 56 44.9
Cape Girardeau, Mo		37 17 53	89 32 54	5 58 11.6
Wittemberg, Mo		37 39 17	89 33 14	5 58 12.9
Menard, Ill	Near Chester	37 53 48	89 51 15	5 59 25.0
Clarksburg, W. Va		39 16 56	80 20 23	5 21 21.5
Grafton, W. Va		39 20 38	80 01 42	5 20 06.8
Cameron, W. Va		39 49 46	80 34 23	5 22 17.5
Wheeling, W. Va		40 04 04	80 43 37	5 22 54.5
Parkersburg, W. Va		39 16 02	81 34 12	5 26 16.8
Point Pleasant, W. Va		38 50 28	82 08 46	5 28 35.0
South Point, Ohio		38 25 14	82 35 27	5 30 21.8
Gauley's Bridge, W. Va		38 09 09	81 12 58	5 24 51.9

APPENDIX No. 6—Continued.

INTERIOR STATIONS—Continued.

Locality.		Latitude.	Longitude. In arc.	Longitude. In time.
		° ′ ″	° ′ ″	h. m. s.
Cumberland, Md		39 39 14	78 45 25	5 15 01.7
Martinsburg, W. Va		39 27 27	77 57 23	5 11 49.5
Staunton, Va		38 08 51	79 04 15	5 16 17.0
Charleston, W. Va		38 21 18	.. .. ..	. .. .
Bristol, Tenn., or Goodson, Va.		36 35 49	82 11 14	5 28 44.9
Austin, Tex	Public reservation	30 16 21	97 44 12	6 30 56.8

NOTE.—In addition to the above, there are available the positions of the light-houses, which may be taken directly from the light-house list of 1874.

APPENDIX No. 7.

TABLE OF DEPTHS.

This table shows the depth of water which can be carried up the channel-ways or over the bars of the harbors or anchorages on the coasts of the United States at the several stages of tide indicated.

Places.	Limits between which depths are given.	Least water in channel-way.				Authorities.
		Average.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	Feet.	Feet.	Feet.	
Kennebec River	On sailing-line up to Hunniwell's Point	25.5	33.6	25.1	34.4	C. S., 1858.
Portland, Me.	From Cape Elizabeth to Portland Light	45	53.9	44.5	54.4	
	From Portland Light to breakwater *	36	44.9	35.5	45.4	
	From breakwater to end of Munjoy Point	30	38.9	29.5	39.4	C. S., 1850, 1853, and 1854. U. S. E., 1874.
	From breakwater to anchorage	21	29.9	20.5	30.4	
	Channel-way off town and wharves	27	35.9	26.5	36.4	
	From Munjoy to railroad bridge	19.5	28.4	19	28.9	
Portsmouth, N. H.	From Whale's Back to Fort Constitution	42	50.6	41.4	51.3	
	From Fort Constitution to the Narrows	51	59.6	50.4	60.3	C. S., 1851.
	From the Narrows to the city	45	53.6	44.4	54.3	
	Off the wharves	63	71.6	62.4	72.3	
Newburyport	Over bar	4	10.8	2.7	11.8	
Ipswich	......do	6	14.6	5.1	15.3	C. S., 1857 and 1872.
Annisquam	......do	6.5	15.5	5.6	16.4	
Gloucester	Channel into Southeast Harbor	30	38.9	29.1	39.8	
	Inner harbor channel to abreast Ten-Pound Island Light	31	39.9	30.1	40.8	C. S., 1854.
	Up into inner harbor	24	32.9	23.1	33.8	
Salem, Mass	Northern ship-channel, between Baker's and Misery Islands	52	61.2	51.3	61.9	
	Southern ship-channel, passing Half-way Rock, Gooseberry and Eagle Islands to the northward, and Cat Island and Coney Island to the southward	28	37.2	27.3	37.9	C. S., 1850 and 1851.
	Inside of Salem Neck	19	28.2	18.3	28.9	
Boston, Mass	Main ship-channel, between Lovell's and Gallop's Island	28.5	38.5	27.8	39.1	
	Broad Sound, south channel	19.5	29.5	18.8	30.1	C. S., 1846.
	President's Roads, anchorage	31.5	41.5	30.8	42.1	C. S., 1847, 1848, and 1853.
	Main ship-channel, between Governor's Island and Castle Island	21	31	20.3	31.6	U. SE., 18.5.
Plymouth	Entrance off Gurnet Lights	21	31.2	20.3	31.7	
	South of Duxbury Pier, in mid-channel	48	58.2	47.3	58.7	
	Up to anchorage inside the pier-head on Long Beach	14	24.2	13.3	24.7	C. S., 1857.
	At anchorage inside the pier-head	24	34.2	23.3	34.7	
	Anchorage in the Cow-Yard	24	34.2	23.3	34.7	
Barnstable Harbor	Over bar	7.7	17.0	6.7	17.5	C. S., 1862.
Narragansett Bay to Prudence Island.	Entering with the Boston Neck on port-hand, Beavertail and Dutch Island Lights on starboard-hand, passing between Conanicut Point and Hope Island	24	28.2	23.6	28.2	C. S., 1873.
	Entering with Beavertail Light on the port and Castle Hill on the starboard hand up to Goat Island	60	63.9	59.6	64.2	
	Anchorage southward and westward of Goat Island	33	36.9	32.6	37.2	
	Abreast of steamboat wharves inside of Goat Island	21	24.9	20.6	25.2	
	From Newport Harbor, inside of Gull Rocks, to Prudence Island	30	33.9	29.6	34.2	C. S., 1873.
	To Mount Hope Bay	42	45.9	41.6	46.2	
	To Mount Hope Bay, with Cormorant Rock, Sachuest Point or Port, and Sakonnet Point on starboard-hand	20	23.9	19.6	24.2	

* The depth in channel-way varies between 6 and 8½ fathoms.

TABLE OF DEPTHS—Continued.

Places.	Limits between which depths are given.	Least water in channel-way. Average. Low water.	Average. High water.	Spring-tides. Low water.	Spring-tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
New York	Gedney's Channel	23	27.8	22.6	28.1	C. S., 1855, 1856, and 1866.
	Swash Channel	22	25.8	20.6	26.1	
	Old South Channel	22	25.8	20.6	26.1	
	Main ship-channel, passing Sandy Hook to Southwest Spit Buoy	31	35.8	30.6	36.1	C. S., 1855.
	Main ship-channel, after passing Southwest Spit Buoy on northeast course, one mile up the bay for New York	23	27.8	22.6	28.1	
Arthur's Kill	Anchorage at Perth Amboy	22	26.9	21.5	27.5	
	From anchorage to Woodbridge Wharf	22	26.9	21.5	27.5	
	From Woodbridge Wharf to Rossville *	13.5	18.6	13.0	19.2	
	From Rossville to Chelsea †	14	19.1	13.5	19.7	
	From Chelsea, in the western channel, to Elizabethport ‡	13	18.1	12.5	18.7	
	From Elizabeth to Shooter's Island §	6.5	10.9	6.0	11.5	C. S., 1855.
Kill Van Kull	From Shooter's Island to Bergen Point Light-House	10	14.3	9.5	14.9	
	From Bergen Point Light-House to New Brighton	27	31.3	26.5	31.9	
Newark Bay	From Bergen Point Light-House to the mouth of Hackensack River ‖	7	11.6	6.5	12.2	
Hudson River	From Castle Garden to Manhattanville	32	36.0	31.6	36.8	
	From Manhattanville to Yonkers	27	30.8	26.7	31.3	
	From Yonkers to Piermont Ferry ¶	39	42.6	38.7	43.0	
	From Piermont Ferry to Sing Sing **	24.5	28.0	24.3	28.3	C. S., 1853.
	From Sing Sing to Haverstraw	26	29.1	25.8	29.8	
	From Haverstraw to Peekskill	27	30.1	26.8	30.8	C. S., 1854.
Delaware Bay	Main ship-channel, passing Delaware breakwater ††	61	64.5	60.4	64.9	
	Off Brandywine Light-House	43	46.5	42.4	46.9	
	Main ship-channel, passing False Liston's Tree to abreast of Bombay Hook Light	27.5	33.4	27.3	34.2	
	Blake's Channel, along Flogger Shoal	13.5	19.4	13.3	20.2	
	Blake's Channel, passing Mahon River Light	13.5	19.4	13.3	20.2	
	Main ship-channel, approaching Liston's Point	20	25.9	19.8	26.7	
Delaware River	Main ship-channel, up to Reedy Island	20	26	19.6	26.3	C. S., from 1840 to 1844, inclusive.
	Main ship-channel, opposite Reedy Island Light-House	24.5	30.5	24.1	30.8	
	Opposite Delaware City	30	36	29.6	36.3	
	Up to Christiana Creek Light	20.5	27	20.3	27.2	
	Up to Marcus Hook	20.5	27	20.3	27.2	
	Opposite Chester	24.5	30.7	24.4	31.2	
	Bar off Hog Island	18.5	24.7	18.4	25.2	
	Between Greenwich Point and Gloucester Point	31.5	37.5	31.4	38.2	
	From Greenwich Point up to Philadelphia	21.5	27.5	21.4	28.2	
Chesapeake Bay	From capes at entrance to Hampton Roads	30	32.5	29.8	32.8	
	Anchorage in Hampton Roads	59	61.5	58.8	61.8	
	From Hampton Roads to Sewall's Point	25	27.5	24.8	27.8	
	South of Sewall's Point, (1¼ miles)	21	23.5	20.8	23.8	C. S., 1852, 1853, 1854, and 1875.
	Up to Norfolk	21	23.5	20.8	23.8	
	From Hampton Roads to James River, entering to the northward of Newport News, middle ground	22	24.5	21.7	24.8	
	From Hampton Roads to James River, entering to the southward of Newport News, middle ground	27	29.5	26.7	29.8	

* Two bars, each a quarter of a mile, have a less depth than 18 feet.

† A small shoal, with 12 feet, lies in the middle of the Kill, opposite the wharf at Blazing Star; and another with 10 eet, a quarter of a mile to the northward; but deeper water is found on east side of both.

‡ A shoal, with 4 feet, obstructs the Eastern Channel, half way between Chelsea and its junction with the main channel.

§ Channel very narrow in the vicinity of Black Beacon.

‖ From Bergen Point Light half way to Newark Bay Light-House 17 eet may be carried.

¶ In a straight line.

** A shoal of 21.5 feet occurs about a mile below Sing Sing.

Soundings varying between 10 and 15 fathoms.

TABLE OF DEPTHS—Continued.

Places.	Limits between which depths are given.	Least water in channel-way.				Authorities.
		Average.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Potomac River	From entrance to Piney Point	42	43.4	41.8	43.9	
	From Piney Point to Lower Cedar Point*	22	23.7	21.8	23.9	
	From Lower Cedar Point to Indian Head	10	20.5	18.8	21.0	C. S., 1864.
	From Indian Head to Washington	15.2	18.1	15.0	18.4	
	From Washington to Georgetown	9.5	12.4	19.3	12.7	
York River, Va.	From abreast the tail of York Spit up to Yorktown	33	35.5	32.7	35.8	C. S., 1852, 1853, and 1854.
James River, Va.	Newport News to Point of Shoals	18.5	21	28	21.4	
	Jamestown to Sandy Point	16	18.5	15.5	18.9	C. S., 1874.
	Sandy Point to Cobham Bar	17	19.5	16.5	19.9	
	Harrison's Bar	13.5	16.3	13.4	16.5	
	Trent's Reach†	8.5	11.7	8.5	11.9	
	Warwick Bar†	12.5	15.9	12.5	15.9	C. S., 1852 and 1859.
	Richmond Bar†	7	9.9	7.0	10.1	
Elizabeth River	Between Norfolk and Navy-Yard	22	24.5	21.8	24.8	1852, 1853, 1854, and 1874
Hatteras Inlet, N. C.	Entrance	19	21	18.9	21.1	C. S., 1857.
	Over bulkhead into Pamplico Sound‡	7	9	6.9	9.1	
Ocracoke Inlet	Over bar	10	12.4	9.8	12.6	1857.
	Anchorage in Wallico's Channel	19	21.4	18.8	21.6	
Currituck Sound	From abreast of Croatan Light-House to a line joining Powell's Point and Shell Bank, near the mouth of Currituck Sound§	7	......	......	......	
	Thence up the sound to Martin's Point§	5.5	......	......	......	1851.
	From Martin's Point to Trout Hole, south of Rattlesnake Island§	5	......	......	......	
North River, N. C.	At entrance and seven miles up from Albemarle Sound§	6.7	......	......	......	1850.
Beaufort, N. C.	Main ship-channel	15.5	18.3	14.8	18.1	C. S., 1862.
	Through the Slue	7	9.8	6.8	10.1	C. S., 1862.
Cape Fear	New Inlet bar, (closed)¶	9	13.5	8	14	1857, 1866.
	Western bar	8	12.5	7.5	13	
Georgetown, S. C.	Entrance to Winyah Bay, east and southeast pass	7	10.8	6.7	11.3	
	Anchorage inside of North Island	27	30.8	26.7	31.3	C. S., 1851, 1852, and 1853.
	Up to Georgetown	9	12.6	8.7	13.1	
Bull's Bay	Over bar	13	17.8	12.6	18.3	1857.
	At anchorage	21	25.8	20.6	26.3	
Charleston, S. C.	Pumpkin Hill channel	11	16.1	10.6	16.5	
	Main channel	13	18.1	12.6	18.5	1870.
	Beach channel	12	17.1	11.6	17.5	
Stono Inlet	Over bar	5.5	11.5	4.9	12.0	1858.
North Edisto	South or main channel	12	17.8	11.5	18.4	1858.
	East channel	10	15.8	9.5	16.4	1862.
St. Helena Sound	South channel	17	22.9	16.3	23.7	1858.
	East channel	16	21.9	15.3	22.7	1858.
South Edisto	......	13	18.9	12.3	19.7	1856 and 1857.
Port Royal Entrance	Southeast channel	21	27.4	20.7	28.0	1862.
	South channel	19.5	25.9	19.2	26.5	1862.
Tybee Entrance	Bar near Tybee Island	18.5	25.5	17.9	26.0	1867.
	Tybee Roads	19	26	18.4	26.5	
Savannah	Channel up to the city, (wrecks and Garden bank)	9	15.5	8.6	16.2	C. S., 1867.
Ossabaw Sound	North channel to Vernon River	8	14.6	7.1	15.1	1860.
	South channel to Vernon River	12	18.6	11.1	19.1	1860.
	South channel to Ogeechee River	13	19.6	12.1	20.1	1860.

* Kettle Bottom Shoals.

† The effect of spring and neap tides is very small. The depth is affected much more sensibly by the stage of the river above.

‡ The tide diminishes rapidly after entering the inlet.

§ There are no lunar tides in Albemarle, Currituck, and Pamplico Sounds.

¶ Channel changes after easterly gales.

TABLE OF DEPTHS—Continued.

Places.	Limits between which depths are given.	Least water in channel-way. Average. Low water.	Average. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Sapelo Sound	Over bar	18	25.0	17.4	25.7	1860.
Doboy Bar, (inlet)	Entrance over bar	15.5	22.1	14.7	22.5	1855.
	Anchorage in sound	24	30.6	23.2	31	
Saint Simon's Sound	Over bar	15	21.8	14.3	22.5	1862.
	Entrance to sound	38	44.8	37.3	45.5	1855 and 1856.
	Turtle River up to Blythe Island	21	27.8	20.3	28.5	
Saint Mary's	Over bar	11	16.8	10.5	17.1	C. S., 1862.
Saint John's River, Fla.	Over bar at entrance	7	11.5	6.4	11.9	1855.
	Channel passing up to Jacksonville	23	25.1	22.5	25.5	
Saint Augustine	Over bar	10	14.3	9.8	14.7	C. S., 1874.
Florida Reef	Approaches to the inside of the reef, Cape Florida Light-House bearing W. S. W. ¾ W	20	21.5	19.9	21.7	1862.
	Entrance to the northward of Fowey Rocks, Soldier Key bearing S. W. ½ W	19	20.5	18.9	20.7	
	Entrance to Legare anchorage	20	21.5	19.9	21.7	
	Turtle Harbor entrance	26	27.5	25.9	27.7	1854.
	Channel inside the reefs, (Hawk Channel,) from entrance off Cape Florida Light-House to Rodrigues Key	11	12.5	10.9	12.7	
	Anchorage one mile from Indian Key	21	22.8	20.7	23.1	
	Bahia Honda Channel, west point of Bahia Honda bearing N. N. W	18	19.3	17.7	19.5	
	Key Sambo Channel, between Middle and Western Sambo	34	35.3	33.7	35.5	
	Inside the reef, and steering W. by N. for buoy	14	15.3	13.7	15.5	
Key West	Main ship-channel to middle buoy on shoals	27	28.3	26.9	28.5	1850 and 1851.
	From shoals to anchorage	30	31.3	29.9	31.5	
	East channel entering	30	31.3	29.9	31.5	
	On course N. N. W. ½ W. (light on O'Hara's observatory) and passing between shoals*	28	29.3	27.9	29.5	
	From Fourteen-feet Shoals to anchorage	30	31.3	29.9	31.5	
	At anchorage	27	28.3	26.9	28.5	
	Rock Key channel	20	21.3	19.9	21.5	
	Sand Key channel	27	28.3	26.9	28.5	
	West channel	30	31.5	29.9	31.5	
	Northwest channel up to abreast northwest light	15	16.3	14.9	16.5	
	Over Northwest channel bar	12	13.3	11.9	13.5	
Tortugas	Northwest channel	43	44.2	42.8	44.4	1874.
	Southwest channel	54	55.2	53.8	55.4	1850 and 1851.
	Eastern channel south of Hospital Key	43	44.2	42.8	44.4	1874.
	Up to abreast of wharf at Fort Jefferson	24	25.2	23.8	25.4	
Tampa Bay	Over bar	22	23.4	21.8	23.4	1874.
	Channel between Egmont and Passage Keys	19	20.4	18.8	20.4	
Waccasassa Bay	Channel up to anchorage	8	10.6	7.7	10.9	1857.
Cedar Keys	Main channel	9				
	Main channel over bar	9	11.5	8.7	11.8	1860.
	North Key channel	5.5	8.0	5.2	8.3	
	Through Northwest channel up to Depot Key	7.5	10.0	7.2	10.3	
Saint Mark's	Over bar	9	11.5	8.7	11.8	1856.
	Channel at middle buoy	12	14.5	11.7	14.8	
	In mid-channel, off light-house	15	17.5	14.7	17.8	
	Up to Fort Saint Mark's	7	9.5	6.7	9.8	1852.
Saint George's Sound	East entrance over bar	15.5	17.1	15.2	17.4	1858.
	Main ship-channel	14.5	16.1	14.2	16.4	1875.

* The highest tides occur at the moon's greatest declination, and are applied in the column headed "Spring tides."

TABLE OF DEPTHS—Continued.

Places.	Limits between which depths are given.	Lowest water in channel-way. Average. Low water.	Average. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	Feet.	Feet.	Feet.	
Saint George's Sound ..	Swash channel	13	14.6	12.7	14.9	
	At anchorage	19	20.6	18.7	20.9	
Apalachicola	Over bar*	13	14.1	12.6	14.4	1858.
	In mid-channel, off beacon on Saint Vincent's Island	39	40.1	38.6	40.4	
	Up to anchorage	10	11.1	9.6	11.4	
Saint Andrew's Bay ...	Main ship-channel, over bar*	13	14	12.8	14.3	
	Swash channel, over bar	7	8	6.8	8.3	1855.
	West Pass, over bar	7	8	6.8	8.3	
Pensacola	Over bar*	22.5	23.5	22.3	23.8	
	From bar to navy-yard	27	28	26.8	28.3	1856.
	Off wharf at Pensacola	21	22	20.8	22.3	
Mobile Bay and River	Over outer bar*	21	22	20.7	22.2	
	Main ship-channel, to Fort Morgan	36	37	35.7	37.2	1847 to 1852, inclusive.
	To the Upper Fleet	12	13	11.7	13.2	
	Grant's Pass*	6.5	7.5	6.3	7.8	1847.
Mississippi Sound	From Grant's Pass to Pascagoula mail-wharf*	7.5	8.7	7.2	9.0	1851.
	Horn Island Pass, over bar	15	16.2	14.7	16.5	1853.
	Anchorage inside Horn Island	19	20.2	18.7	20.5	1852, 1853.
	Up to Pascagoula mail-wharf	8	9.2	7.7	9.5	
Ship Island Harbor	Channel*	19	20.3	18.7	20.6	
	Northwest channel	19.5	20.8	19.2	21.1	1848.
	Anchorage, Man-of-War Harbor	18	19.3	17.7	19.6	
Cat Island Harbor	Ship channel*	16	17.3	15.7	17.6	
	South Pass	14	15.3	13.7	15.6	1848.
	Shell-bank channel	15.2	16.5	14.9	16.8	
Mississippi delta	Pass à Loutre, north channel*	9.5	10.6	9.3	10.7	
	South channel	12	13.1	11.8	13.2	
Northeast Pass	Over bar, north entrance*	7	8.1	6.8	8.2	1851.
Southeast Pass	Entering* (Not known)	......	......	......	......	
South Pass	Channel* do	......	......	......	......	
Southwest Pass	Channel†	15	12.3	10.9	12.4	1870.
Barrataria Bay	Over bar, outside of Grand Pass*	7.5	8.7	7.2	8.9	1852.
	Grand passage to Independence Island	15	16.2	14.7	16.4	
Dernière or Last Island	Channel inside and north of Ship Island Shoal light-ship*	27	28.4	26.7	28.8	1853.
	Channel north of Ship Island Shoal, one mile from beach of Dernière Island	14	15.4	13.7	15.8	1853.
Atchafalaya Bay	From entrance to Cut-off Channel bouy*	8	9.6	7.6	10.0	
	On the Narrows	6.5	8.1	6.1	8.5	1858.
	On Bulkhead	6.5	8.1	6.1	8.5	
	Mouth of Atchafalaya River in mid-channel	48	49.6	47.6	50.0	
Vermillion Bay	In mid-channel off light-house	42	43.6	41.6	44.0	1855.
Calcasieu River	Entrance over bar*	5.5	7.4	5.3	7.6	
Sabine Pass	Across the bar*	7.5	9	7.2	9.3	
Galveston Bay	Entrance over bar‡	12	13.1	11.7	13.3	
San Luis Pass	Over bar*	8	9.1	7.8	9.3	1855.
Brazos River	Over bar*	8	9.1	7.8	9.3	
Matagorda Bay	Entrance over bar*	7.5	9.1	7.3	9.3	1874.
Aransas Pass	Aransas Pass*	6.5	8.1	6.2	8.2	1875.
Rio Grande	Channel*	4	4.9	3.8	5	1853.

* The highest tides occur at the moon's greatest declination, and are applied in the column headed "Spring tides."

† Channel has changed since 1870, and is filling up. New entrance being improved at South Pass.

‡ Bar has changed greatly since 1875—September—and there has been no new survey since the great gale at that time; ten feet at low water now reported.

TABLE OF DEPTHS—Continued.

PACIFIC COAST.

Places.	Localities for which depths are given.	Average stages of tide.			
		Lower low water.	Higher high water.	Lowest observed.	Highest observed.
		Feet.	*Feet.*	*Feet.*	*Feet.*
San Diego		22	27.5	19.6	28.4
Santa Monica	Anchorage	25	....	....	....
	Wharf end	19	....	....	....
Santa Barbara	Outer anchorage	42	47.7	40.9	49.1
	Inside	21	26.7	19.9	28.1
Cuyler's Harbor		36	41.8	35.2	43
San Francisco	Outer bar	30	35.4	28.7	36.3
	San Pablo Bay	21	27.7?	19.7	28.9
	Mare Island Straits	21	27.7	....	....
	Karquines Straits, opposite Benicia	21	27	19.4	28.2
Sacramento River	Entrance	10	15.3	9.5	15.8
San Joaquin River	......do	21	26.3	20.5	26.8
Drake's Bay	Anchorage	21	26.4	19.6	28
Tomales Bay	Bar	10	15.4	9	17
Humboldt Bay to Eureka		12	18.1	10.2	19.9
Trinidad Harbor	Anchorage	42	47.7	40.5	51.6
Cape Orford	......do	21	28	18.4	29.2
Crescent City Bay		20	27.1	18.3	28
Koos Bay	Entrance, (shifting)	7	12.4	5.9	12.9
Umpquah River	......do	12	19.0	9.4	20.2
Shoalwater Bay	To anchorage, (shifting)	11	19	9.2	21.8
Gray's Harbor, (shifting)		17	25	15.2	27.8

APPENDIX No. 8.

ON THE SECULAR CHANGE OF MAGNETIC DECLINATION IN THE UNITED STATES AND OTHER PARTS OF NORTH AMERICA: NEW DISCUSSION BY CHARLES A. SCHOTT, ASSISTANT COAST SURVEY.

AUGUST, 1874.

The present investigation* incorporates the additional observations made or collected since 1859, and contains the improved results for the old stations as well as those for a number of new stations. The circular function† adopted in the previous discussion to represent the secular change continued to lead to satisfactory results, as might be expected from its great adaptation to represent curves of a periodic character. Independently of the study of terrestrial magnetism, the necessity of the occasional reconstruction of the numerical expressions is sufficiently apparent from the demands of the Survey and the use which is made of them for furnishing the magnetic data given on our charts, viz, the magnetic declination (variation of compass) for a certain epoch, or date of publication, and its rate of change.

To briefly recapitulate the formulæ employed, let

$$D = \delta + r \sin (\alpha m + c) + r_1 \sin (\alpha_1 m + c_1) + \ldots\ldots$$

express the magnetic declination at any time t, positive when west, negative when east of north; also let

$$m = \text{number of years (and fraction of a year) from the adopted epoch } t, \text{ or } m = t - 1850$$

$$\alpha \quad \alpha_1 \ldots \text{ factors depending on the adopted periods } p \quad p_1 \ldots \text{ or } \alpha = \frac{360^\circ}{p}, \quad \alpha_1 = \frac{360^\circ}{p_1}, \cdots$$

The quantities, δ, a constant representing a mean declination, $r \quad r_1 \ldots.$ parameters, and $c \quad c_1 \ldots$ epochal constants of the periodic terms, are to be determined from the observations at any one place by the application of the method of least squares in order to satisfy the condition that the sum of the squares of the residuals of the observed and computed declinations shall be a minimum ($\Sigma \Delta^2 =$ a minimum). For this purpose, put $\delta = \delta_1 + x$, where $\delta_1 =$ an assumed approximate value of δ and x a correction to it; also,

$$r \cos c = y \text{ and } r \sin c = z$$

then the conditional equations will take the form

$$0 = \delta_1 - D + x + \sin \alpha m \,.\, y + \cos \alpha m \,.\, z + \ldots.$$

which are to be treated in the usual manner. To determine the values of $\alpha \quad \alpha_1 \ldots$ three (or more, if necessary) assumptions are made, and those values which render $\Sigma \Delta^2$ a minimum are deduced and finally adopted. In some cases, where certain observations were evidently less trustworthy than others, and which nevertheless could not be dispensed with on account of the small number of observations, or on account of their reference to desirable epochs, special weights were assigned; generally observations received the weight unity, a few imperfect observations the weight one-half. Of observations evidently grossly in error, no notice was taken. When applying Cauchy's method of interpolation the form

$$D = \delta + r \cos c \,.\, \sin m\alpha + r \sin c \,.\, \cos m\alpha + \ldots.$$

was found convenient for use.

The second periodic term depending on $r_1 \quad \alpha_1 \quad c_1$ could only be established for a few places, owing to insufficiency in the number of observations, and their want of the greater accuracy demanded for it.

* This is an extension of my paper contained in the Coast Survey Report for 1859, Appendix No. 24, pp. 296–305.

† A slight alteration has been made by the substitution of a sine for a cosine function and by changing the epoch from 1830 to 1850; some use has also been made of Cauchy's method of interpolation, especially for the establishment of the second periodic terms.

The annual change v in the magnetic declination, positive when increasing west (or decreasing east); also the epoch of minimum west declination (or of maximum east declination); also its amount, and the apparent probable error of an observation, are found as follows:

Differentiating the expression for D, we have

$$dD = ra \cos (am + c)\, dm + r_1 a_1 \cos (a_1 m + c_1)\, dm + \ldots.$$

hence for any time t, and for minutes of arc,

$$v = 60 \sin 1^\circ \left[ra \cos (am + c) + r_1 a_1 \cos (a_1 m + c_1) + \ldots \right]$$

Maxima and minima are deduced from the equation

$$0 = ra \cos (am + c) + r_1 a_1 \cos (a_1 m + c_1) + \ldots$$

from which expression we can find m.

The apparent probable error e_0 of an observation is deduced from the differences Δ of the n observed and computed values by the formula

$$e_0 = \sqrt{\frac{0.455\ \Sigma\Delta^2}{n - n_1}}$$

where n_1 equals the number of unknown quantities in the expression of D which had to be found from the observations; when weights w are used, substitute $w\Delta^2$ for Δ^2. The greater part of this apparent probable error is due to the fact that the observations collected at any one station were not generally made at the same spot; it includes consequently local irregularities in the distribution of magnetism as well as pure observing errors.

The principal uncertainty in the investigation arises partly from the large observing errors in the older observations made with ordinary compasses or rude instruments generally, and partly, since the introduction of the refined instruments, the theodolite and magnetometer, from the circumstance that the various observations for the same nominal locality were taken at different spots, involving changes of local deflections of the magnet. From the extended use of iron and the growth of cities, it is difficult to select and preserve at such places a suitable locality for use at future times. Accurate investigations of the secular change can only be made at permanent observatories or in localities not liable to disturbing influences.

Some remarks respecting a supposed cause of the secular change in the magnetic declination, dip, and intensity will be found in Coast Survey Report for 1870, Appendix No. 14, pp. 107–110; and, in applying at present a periodic function to the investigation of the secular change, it is not *implied* that the phenomenon is necessarily of a periodic character, or must exhibit more than a single *complete* period; the aim is to represent by means of such a function the changes in the direction of the magnetic resultant as far as observed. In the present state of our information, the process must necessarily be a tentative one.

The collection of the material is given first, the stations being arranged in geographical order, beginning in the northeast, passing to the south and west, and ending in the northwest.* For each locality, the observed declinations are given in chronological order, together with such notes and references respecting observer, place, and publication, etc., as could be found. The stations here given are the only ones, as far as known, at present suitable for a discussion of the secular change, but their number is continually increasing by the accumulation of new facts.

* This approximates to an arrangement proceeding from the greatest western to the greatest eastern declinations.

Collection of Magnetic Declinations, observed at various places in the United States and in adjacent countries, from the earliest to the present time, and found suitable for investigating the secular changes.

HALIFAX, NOVA SCOTIA.*

$\phi = 44° 39'.6$ $\lambda = 63° 35'.3$ W. of Gr.

(Naval-yard observatory.)

		°	′		
1	1756	12	50	W.	From MS. map by Charles Morris, assistant surveyor.
2	1775	13	35	W.	Des Barres' Sailing Directions.
3	1798	16	30	W.	Published plan of Thomas Backhouse.
4	1818 (about)	17	28	W.	Remark-book of J. Napier, master R. N., as given by Anthony Lockwood, esq.
5	1821, June and November	17	36	W.	Remark-book of J. Napier, master R. N., as observed by himself, viz, in June, 17° 38′.2; in November, 17° 33′.5.
6	1852–53	18	10	W.	Captain Bayfield, MS. survey.
7	1852–53	18	51	W.	Remark-book of J. Hill, master R. N., viz, August, 1852, 18° 46′; September, 1852, 19° 21′; August, 1853, 18° 25′.
8	1860, July 22	19	55	W.	Captain Orlebar, R. N.
9	1866, April	21	05.6	W.	Halifax dock-yard, in $\phi = 44° 40'$, $\lambda = 63° 25'$ W.; declination, April 1, 9 a. m., 20° 55′.0; April 3, 3 p. m., 21° 16′.3.

* For the collection and communication of the observed values at Halifax, Nova Scotia, the Coast Survey is indebted to Staff-Commander Fred. Jno. Evans, R. N. (now Hydrographer to the Admiralty.) [Letters dated January 5, 1866, and April 26, 1867.]

QUEBEC, CANADA.

$\phi = 46° 48'.4$ $\lambda = 71° 14'.5$ W. of Gr.

		°	′		
1	1649	16		W.	P. Bressani; Hansteen's Magnetismus der Erde, 1819; also Barlow in Encyc. Metrop., 1848.
2	1686	15½		W.	De Hayes; references as above.
3	1810	11		W.	Becquerel's Traité du Magnétisme, Paris, 1846.
4	1814	11	50	W.	Kent; Becquerel's Traité du Magnétisme.
5	1831	13	38	W.	Bayfield; Becquerel's Traité du Magnétisme.
6	1834	14	14	W.	Bayfield; Contributions to Terr. Magnetism, No. xiii, by Gen. Sir E. Sabine, June, 1872, Trans. Roy. Soc.
7	1842	14	12	W.	Captain Lefroy, R. E., Phil. Trans. Roy. Soc., 1849, Part ii.
8	1858, October 8	15	34	W.	Captain Orlebar, R. N., communicated by Capt. F. J. Evans, Hydrographic Department, Admiralty.
9	1859, July 19	16	17	W.	Charles A. Schott, assistant Coast Survey, Report of 1859, p. 296.
10	1860, October 12	16	28	W.	Captain Orlebar, R. N., communicated by Capt. F. J. Evans, Hydrographic Department, Admiralty.

YORK FACTORY, HUDSON BAY.

$\phi = 57° 00'$ $\lambda = 92° 26'$ W. of Gr.

		°	′		
1	1725	19	00	W.	Captain Middleton; Hansteen's Magnetismus der Erde, 1819; also Gen. Sir E. Sabine, Proc. of the Roy. Soc., 1858.
2	1787	5	00	W.	Hansteen's map; references as above.
3	1819, September	6	00	E.	Sir J. Franklin, in $\phi = 57° 00'$, $\lambda = 92° 26'$; Gen. Sir E. Sabine, Proc. Roy. Soc., 1858, and Cont. to Terr. Mag., No. xiii, Phil. Trans. Roy. Soc., 1872.
4	1843, July	9	25	E.	Captain Lefroy, R. A.; references as above.
5	1857, August	7	37	E.	Captain Blakiston, R. A.; references as above.

Collection of Magnetic Declinations, etc.—Continued.

PORTLAND, ME.

$\phi = 43° 38'.8$ $\lambda = 70° 16'.6$ W. of Gr.

(Bramhall Hill.)

		° ′	
1	1763	7 45 W.	Prof. John Winthrop, at Falmouth, in $\phi = 43° 39'$, $\lambda = 70° 19'$; Sill. Jour., vol. xvi, 1829, and Prof. E. Loomis' remarks on the Winthrop Table in Sill. Jour., vol. xxxiv, 1838.
2	1775	8 30 W.	J. F. W. Des Barres' Atlantic Neptune, London, 1781.
3	1845, June 4	11 28.3 W.	Dr. J. Locke, in $\phi = 43° 41'$, $\lambda = 70° 20'$; Smithsonian Contributions to Knowledge, vol. iii, 1852.
4	1851, August 18, 20	11 41.1 W.	J. E. Hilgard, assistant Coast Survey, at Bramhall Hill, in $\phi = 43° 38'.8$, $\lambda = 70° 16'.6$; Coast Survey Report for 1854, p. *143.
5	1859, July 15	12 20 W.	C. A. Schott, assistant Coast Survey, at Bramhall Hill; Coast Survey Report of 1859, p. 296.
	1863, July 6	12 18.1 W.	C. A. Schott, assistant Coast Survey, at Mount Joy Observatory, in $\phi = 43° 39'.9$, $\lambda = 70° 14'.9$; Coast Survey Report of 1863, p. 204. [Not used.]
6	1863, July 15	12 28.2 W.	C. A. Schott, assistant Coast Survey, at Bramhall Hill, in $\phi = 43° 38'.8$, $\lambda = 70° 16'.6$; Coast Survey Report of 1863, p. 204.
7	1864, August to December.	12 43.7 W.	Prof. H. W. Richardson, observer for United States Coast Survey, at Bramhall Hill; monthly determinations on four days, about the middle of each month; MS. in Coast Survey archives.
8	1865, January to December	12 42.3 W.	
9	1866, January to March (inclusive).	12 42.9 W.	
10	1873, September 8, 9, 11	12 43.3 W.	Dr. T. C. Hilgard, observer for United States Coast Survey, at Mount Joy Observatory, two stations; MS. in Coast Survey archives; to refer to Bramhall Hill, add 10′.

BURLINGTON, VT.

$\phi = 44° 28'.2$ $\lambda = 73° 12'.3$ W. of Gr.

(Coast Survey astronomical station.)

		° ′	
1	1793	7 38 W.	Doctor Williams — Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838; in $\phi = 44° 28'$, $\lambda = 73° 14'$.
2	1818	7 30	J. Johnson
3	1822	7 42	J. Johnson
4	1826	7 36	Prof. G. W. Benedict; Prof. E. Loomis' collection in Sill. Jour., vol. xxxix, 1840; in $\phi = 44° 27'$, $\lambda = 73° 10'$.
5	1830	8 10	J. Johnson — Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
6	1831	8 15	J. Johnson
7	1832	8 25	J. Johnson
8	1834	8 50	J. Johnson
9	1837	9* 45	Professor Benedict; Thompson's History of Vermont.
	1840	9 42	J. Johnson; Thompson's History of Vermont. [Not used.]
10	1845, June 26	9 22	Dr. J. Locke, in $\phi = 44° 27'$, $\lambda = 73° 10'$; Smithsonian Contributions to Knowledge, vol. iii, 1852.
11	1855, August 28	9 57.1	C. A. Schott, assistant Coast Survey, in $\phi = 44° 29'.3$, $\lambda = 73° 13'.4$, at encampment flag-staff, near shore of the lake; Coast Survey Report of 1855, p. 337.
12	1873, October 14, 15	11 19.0 W.	Dr. T. C. Hilgard, observer for United States Coast Survey; MS. in Coast Survey archives.

* Supposed misprint for 8°.

RUTLAND, VT.

$\phi = 43° 36'.5$ $\lambda = 72° 55'.5$ W. of Gr.

		° ′	
1	1789, April	7 03 W.	Dr. Williams; Sill. Jour., vol. xvi, 1829.
2	1810, May	6 04 W.	
3	1811, September	6 01 W.	
4	1859, July 21	9 49 W.	C. A. Schott, assistant Coast Survey; near new post-office; Coast Survey Report for 1859, p. 296.
5	1873, October 17, 18	10 40.2 W.	Dr. T. C. Hilgard, observer for United States Coast Survey; MS. in Coast Survey archives.

Collection of Magnetic Declinations, etc.—Continued.

PORTSMOUTH, N. H.

$\phi = 43° 04'.8$ $\lambda = 70° 43'.0$ W. of Gr.

(Kittery Point.)

		°	′		
1	1771	7	46	W.	Holland, at Kittery, in $\phi = 43° 06'$, $\lambda = 70° 45'$, Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
	1771	7	48	W.	Holland, in $\phi = 43° 05'$, $\lambda = 70° 45'$. [Not used].
2	1775	7	45	W.	J. F. W. Des Barres' Atlantic Neptune, London, 1781.
3	1850, August 28, September 12.	10	30.2	W.	J. E. Hilgard, assistant Coast Survey, at Kittery Point; Coast Survey Report of 1854, p. *143.
4	1859, July 14	11	15	W.	C. A. Schott, assistant Coast Survey; at Kittery Point, Coast Survey Report of 1859, p. 296.

NEWBURYPORT, MASS.

$\phi = 42° 48'.4$ $\lambda = 70° 49'.0$ W. of Gr.

(Plum Island lights.)

		°	′		
1	1775	6	45	W.	J. F. W. Des Barres' Atlantic Neptune, London, 1781; north of Cape Ann, opposite Newburyport.
2	1781	7	18	W.	Dr. Williams, in $\phi = 42° 48'$, $\lambda = 70° 52'$; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
3	1850, September 18–20	10	05.6	W.	J. E. Hilgard, assistant Coast Survey, on Plum Island, in $\phi = 42° 48'.0$, $\lambda = 70° 48'.8$; Coast Survey Report for 1854, p. *143.
4	1859, July 13	10	58	W.	C. A. Schott, assistant Coast Survey; same position as above; Coast Survey Report for 1859, p. 296.

SALEM, MASS.

$\phi = 42° 31'.9$ $\lambda = 70° 52'.5$ W. of Gr.

(Fort Lee.)

		°	′		
1	1781, August	7	03	W.	President Willard, at Beverly, in $\phi = 42° 33'$, $\lambda = 70° 54'$, mean of seven observations; Sill. Jour., vol. xvi, 1829; reduction to Salem, −8′.
2	1805, November	5	57	W.	Dr. Bowditch, in Summer street, Salem, from 115 observations.
	1808, June	5	20	W.	Dr. Bowditch, one-eighth of a mile south of above place, from 112 observations. [Not used.]
3	1810, April	5 5	47.7 13.4	W. W.	Dr. Bowditch, about one-fourth of a mile east of the place of 1805. [Second value not used.]
	1810, April, to 1811, May	6	22.6	W.	Dr. Bowditch, result by a third needle from 5125 observations of monthly values. Mean of two needles, + 6°.09 in 1810.5. Reference to Nos. 2, 3, Sill. Jour., vol. xvi, 1829.
4	1849, August 20	10	14.5	W.	Prof. G. W. Keely, for United States Coast Survey, at Fort Lee; Coast Survey Report for 1854, p. *143.
5	1855, August 25	10	49.7	W.	C. A. Schott, assistant Coast Survey, at Fort Lee; Coast Survey Report for 1855, p. 337.

Collection of Magnetic Declinations, etc.—Continued.

BOSTON, MASS.

$\phi = 42° 21'.5$ $\lambda = 71° 03'.8$ W. of Gr.

(State-house.)

		° ′		
1	1700	10	W.	Prof. J. Winthrop's table,† Sill. Jour., vol. xvi, 1829 (also Mem. Am. Acad., vol. ii, new series, Cambridge, 1846); also Coast Survey Report for 1855, p. 316.
2	1708	9	W.	Mathews, observer, Sill. Jour. for 1829, Dr. N. Bowditch; also Encyc. Met., 1848.
3	1741	7 30	W.	Mathews; Encyc. Met., 1848.
4	1775–76	7 40	W.	Des Barres' Atlantic Neptune, London, 1781.
5	1782	7 00	W.	Sill. Jour. for 1829, Dr. N. Bowditch; see also first vol. Mem. Am. Acad.
6	1793	6 30	W.	Mean of 1644 observations; Mem. Am. Acad., new series, Cambridge, 1846.
7	1807	6 05	W.	Communicated by W. Rotch, letter dated Fall River, February 17, 1874.
8	1839	9 06	W.	Bond, at Dorchester, in $\phi = 42° 19'$, $\lambda = 71° 04'$; Prof. E. Loomis' collection in Sill. Jour., vol. xxxix, 1840.
9	1846, September 6–8	9 31.4	W.	Lieut. T. J. Lee, assistant Coast Survey, at Dorchester Heights, South Boston, in $\phi = 42° 20'.0$, $\lambda = 71° 02'.5$; Coast Survey Report for 1854, p. *143.
10	1855, August 24	10 13.7	W.	C. A. Schott assistant Coast Survey, in South Boston, locality as above; Coast Survey Report of 1855, p. 337.
11	1872, September 28, 30, October 1.	11 15.2	W.	A. H. Scott, United States Coast Survey; locality as above; MS. in Coast Survey archives.

† In this table the observed and interpolated values were pointed out by Prof. E. Loomis; no notice is taken of the latter values.

Collection of Magnetic Declinations, etc.—Continued.

CAMBRIDGE, MASS.

$\phi = 42° 22'.9$ $\lambda = 71° 07'.7$ W. of Gr.

(Harvard College observatory.)

		° ′		
1	1708	9	W.	Brattle, observer; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838 (same reference for Nos. 2, 3, 4, 7, and 9); Mem. Am. Acad., vol. ii, new series, Cambridge, 1846; also Encyc. Met., 1848; also Coast Survey Report for 1855, p. 317.
2	1742	8	W.	Prof. J. Winthrop's table,* Sill. Jour., vol. xvi, 1829; also Mem. Am. Acad., vol. ii, new series, Cambridge, 1846.
3	1757	7 20	W.	Prof. J. Winthrop; reference as above.
4	1761	7 14	W.	Dr. Williams, Mem. Am. Acad., vol. ii, 1846.
5	1763	7 00	W.	Prof. J. Winthrop; Sill. Jour., vol. xvi, 1829.
6	1780	7 02	W.	Dr. Williams; Encyc. Met., 1848.
7	1782	6 45	W.	Dr. Williams; Encyc. Met., 1848; in Mem. Am. Acad., 1846, 6° 46′.
	1782	6 44	W.	Prof. Sewall (mean of extremes 6° 21′ and 7° 08′); Sill. Jour. for 1829. See also first vol. of Mem. Am. Acad.
8	1783	6 52	W.	Dr. Williams; Mem. Am. Acad., 1846; also Encyc. Met., 1848.
9	1788	6 38	W.	Dr. Williams; Mem. Am. Acad., 1846.
10	1810	7 30	W.	Prof. Farrar; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
11	1835	8 51	W.	
12	1837	9 09	W.	Mem. Am. Acad.; Cambridge, 1846.
13	1840.4	9 18	W.	W. C. Bond, director Har. Coll. observatory, observer. Mem. Am. Acad., 1846. See also Phil. Trans. Roy. Soc., 1849.
14	1842.2	9 34.9	W.	Prof. J. Lovering; Mem. Am. Acad., vol. iv, 1850. Half-hourly observations during one year, Oct., 1841, to Oct., 1842.
15	1844	9 39	W.	W. C. Bond, director Har. Coll. observatory; MS. communicated by Professor Lovering.
16	1845, June 2	9 32	W.	Dr. J. Locke, Smithsonian Contributions to Knowledge, vol. iii, 1852.
17	1850, August 9	9 30	W.	Lieut. J. C. Ives, at Har. Coll. observatory; Coast Survey Report for 1856, p. 222.
18	1852	10 08	W.	W. C. Bond, director Har. Coll. observatory. Communicated in a letter by Prof. Lovering (May 29, 1855).
19	1854	10 39	W.	
	1854, May 10	9 46	W.	Lieut. J. C. Ives, at Har. Coll. observatory. [Used mean value for 1854.]
20	1855, May 22, 23	10 54.6	W.	W. C. Bond, director Har. Coll. observatory. Communicated by W. C. B., Dec. 24, 1858.
21	1856, May 16	10 50.3	W.	W. C. Bond; reference as above.
	1856, July 17	10 06	W.	Karl Friesach, at Cambridge observatory; Berichte der Kais. Acad. der Wiss., Vienna, vol. 29, 1858. Result corrected for diurnal variation.
22	1859, March	10 48	W.	Lieut. W. P. Smith, U. S. T. E., at Har. Coll. observatory. Communicated by Capt. G. G. Meade, U. S. T. E.
23	1866–67–68	10 41	W.	Prof. J. Winlock, director Har. Coll. observatory; from a large number of observations communicated in November, 1872 [and computed by me]. Mean epoch 1867.5.

* In this table, the observed and interpolated values were pointed out by Prof. E. Loomis; no notice is taken of the latter values.

Collection of Magnetic Declinations, etc.—Continued.

NANTUCKET, MASS.

$\phi = 41° 17'.0$ $\lambda = 70° 06'.0$ W. of Gr.

(Mitchell's observatory.)

		° '	
1	1775	6 30 W.	J. F. W. Des Barres' Atlantic Neptune, London, 1781.
	1776	6 30	From a chart, Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838. Probably of the same origin as No. 1. [Not used.]
2	1834	8 27	W. Mitchell; in Sill. Jour., vol. xlvi.
3	1838.9	9 02.3	
4	1842, August and September.	9 09	
5	1843, September	9 10	
6	1846, July 30, 31	9 14.0	Lieut. T. J. Lee, U. S. N., assistant United States Coast Survey; at Mitchell's house. Coast Survey Report of 1854, p. *143.
7	1855, August 22	9 58.3	C. A. Schott, assistant United States Coast Survey; near Nantucket Harbor light, north of Mitchell's house, on beach, in $\phi = 41° 17'.5$, $\lambda = 70° 06'.0$. Coast Survey Report of 1855, p. 337.
8	1867, May 28, 29, 30	10 19.9 W.	C. O. Boutelle, assistant United States Coast Survey; at Nantucket Cliff, in $\phi = 41° 17'.2$, $\lambda = 70° 06'.3$. MS. in Coast Survey archives.

PROVIDENCE, R. I.

$\phi = 41° 49'.5$ $\lambda = 71° 24'.1$ W. of Gr.

(Brown University.)

		° '	
1	1717*	9 36 W.	The recorded declinations between 1717 and 1843 inclusive are given by M. B. Lockwood, civil engineer, from actual observations and recorded bearings of a number of permanent objects, in Sill. Jour., vol. xliv, 1843.
2	1720	9 28	
3	1725	9 14	
4	1730	8 54	
5	1735	8 39	
6	1740	8 15	* NOTES.—Observation of 1717, R. Jackson, on a map of Providence.
7	1745	7 59	
8	1750	7 40	Observation of 1769, Dr. B. West.
9	1755	7 21	Observation of 1815 by M. Brown, B. Lockwood, and G. Sheldon.
10	1760	6 57	Observation of 1835; since this time the observations were made more carefully.
11	1765	6 43	
12	1769*	6 30	[There can be no doubt that this table, like that of Hatboro', Pa., depends in part on interpolation. It is well graduated, and unquestionably rests on reliable observations.—Sch.]
13	1775	6 20	
14	1780	6 16	
15	1785	6 13	
16	1790	6 10	
17	1795	6 10	
18	1800	6 15	
19	1805	6 19	
20	1810	6 24	
21	1815*	6 30	
22	1819	6 37	
23	1825	6 51	
24	1830	7 10	
25	1835*	7 34	
26	1840	8 25	
27	1841	8 31	
28	1842	8 39	
29	1843	8 46	
30	1855, August 20	9 31.5 W.	C. A. Schott, assistant, Coast Survey, grounds east of Brown University, in $\phi = 41° 49'.5$, $\lambda = 71° 24'.1$; Coast Survey Report for 1855, p. 337.

Collection of Magnetic Declinations, etc.—Continued.

HARTFORD, CONN.

$\phi = 41° 46'.0$ $\lambda = 72° 40'.8$ W. of Gr.

(State-house.)

		° ′		
1	1786	5 25	W.	Dr. Williams; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
2	1810	4 46	W.	Asher Miller, at East Hartford, in $\phi = 41° 46'$, $\lambda = 72° 38'$; reference as above.
3	1824	5 45	W.	N. Goodwin; reference as above.
4	1828	6 03	W.	
5	1829	6 03	W.	
6	1859, July 27	7 17	W.	C. A. Schott, assistant Coast Survey, in City Park; Coast Survey Report for 1859, p. 296.
7	1867, August 15, 17	7 49.3	W.	C. A. Schott, assistant Coast Survey, in $\phi = 41° 45'.9$, $\lambda = 72° 40'.8$, near the Athenæum; MS. in Coast Survey archives.

NEW HAVEN, CONN.

$\phi = 41° 18'.5$ $\lambda = 72° 55'.7$ W. of Gr.

(Yale College.)

		° ′		
1	1761	5 47	W.	President Stiles... } Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
2	1775	5 25		Professor Strong..
3	1780	5 15		President Stiles...
4	1811	5 10		Nathan Redfield ..
	1818, August	5 45		Hon. De Witt, Sill. Jour., vol. xvi, 1829. [Not used.]
	1819	4 35		Professor Fisher, of Yale College; Prof. E. Loomis' collection of 1838. [Not used. See below.]
5	1819, May 1820, April	4 25.4		Professor Fisher, from hourly observations; Sill. Jour., vol. xvi, 1829.
6	1828	5 17		N. Goodwin; Prof. E. Loomis' collection, 1838.
7	1834, November 1835, November	5 40.6		Prof. E. Loomis, from hourly observations; Sill. Jour., vol. xxx, 1836.
	1835	5 52		Prof. E. Loomis, in his collection of 1838. [Not used.]
8	1836	5 55		E. C. Herrick; Prof. E. Loomis' collection of 1838.
9	1837, November	5 50		E. C. Herrick; Sill. Jour., vol. xxxiv, 1838.
10	1840	6 10		E. C. Herrick; Prof. E. Loomis' collection, Sill. Jour., vol. xxxix, 1840.
11	1845, September 10	6 17.3		Prof. J. Renwick, United States Coast Survey, Pavilion Hotel, south of college, near bay; Coast Survey Report for 1854, p. *143.
	1847, September 25 and October 2.	7 27.2		R. H. Fauntleroy, assistant Coast Survey, at Fort Wooster, in $\phi = 41° 16'.9$, $\lambda = 72° 53'.6$; Coast Survey Report for 1854, p. *143. [Not used.]
	1848, August 21 to 29	7 25.5		J. S. Ruth, subassistant Coast Survey; references as above. [The observations at Fort Wooster are not used; affected by local attraction.]
12	1848, August 10 to 14	6 37.9		J. S. Ruth, United States Coast Survey, Pavilion Hotel; Coast Survey Report for 1854, p. *143.
	1848, August 30, September 1.	6 31.9		J. S. Ruth, United States Coast Survey, at Oyster Point, in $\phi = 41° 17'.0$, $\lambda = 72° 55'.7$ (meridian of Yale College); Coast Survey Report for 1854, p. *143.
13	1855, August 17	7 02.7		C. A. Schott, assistant Coast Survey, at Oyster Point, in $\phi = 41° 16'.9$, $\lambda = 72° 55'.8$; Coast Survey Report for 1855, p. 337.
	1871, March	7 22		G. H. Mann, C. E., United States Engineers' survey of harbor of New Haven, on College Green; MS. communication. [Not used.]
14	1872	8 27.5		R. M. Bache, assistant Coast Survey; topographical and hydrographical survey of New Haven Harbor and vicinity, from bearings of trigonometrical lines. Hydrographic chart No. 1170.

Collection of Magnetic Declinations, etc.—Continued.

ALBANY, N. Y.

$\phi = 42° 39'.2$ $\lambda = 73° 45'.8$ W. of Gr.

(State Capitol.)

		° ′	
1	1817, October	5 44 W.	De Witt, in $\phi = 42° 39'$, $\lambda = 73° 44'$; Sill. Jour., vol. xvi, 1829.
2	1818, August	5 45 W.	
3	1825, April	6 00 W.	
4	1828	6 14 W.	Geological Report, State of New York, and Sill. Jour., vol. xxxix, 1840.
	1828, September	6 16 W.	
	1828, September	6 18 W.	
5	1830, June	6 18 W.	
6	1831, May	6 25 W.	
	1831	6 32 W.	
	1831, November	6 40 W.	Regents' Report.
7	1834, October	6 40 W.	Regents' Report, and Sill. Jour., vol. xxxiv, 1838.
8	1836, October	6 47 W.	
9	1847, November	7 35 W.	Regents' Report.
10	1855, August 31	7 51.7 W.	C. A. Schott, assistant Coast Survey, at Greenbush, in $\phi = 42° 37'.8$, $\lambda = 73° 44'.3$; Coast Survey Report of 1855, p. 337.
11	1856, September 1	8 39.2 W.	Karl Friesach, in Berichte der Kai. Acad. Vienna, vol. 29, 1858; 8° 35′ when corrected for diurnal variation.
12	1858, May 12–14	8 17.0 W.	G. W. Dean, assistant Coast Survey, at Dudley Observatory, in $\phi = 42° 39'.8$, $\lambda = 73° 44'.9$; Coast Survey Report of 1858, p. 191.

OXFORD, CHENANGO COUNTY, N. Y.

$\phi = 42° 26'.5$ $\lambda = 75° 40'.5$ W. of Gr.

		° ′	
1	1792 to 1795	3 W.	E. B. W. Call, surveyor, in a letter to the Superintendent of the Coast Survey, dated December 22, 1858.
2	1817	3 W.	E. B. W. Call, in $\phi = 42° 26'.5$, $\lambda = 75° 42'$.
3	1828, July 7	4 30 W.	
4	1834, October 9	3 52 W.	Regents' Report, in $\phi = 42° 28'$, $\lambda = 75° 33'$; also Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
5	1836, October 5	4 09 W.	
6	1837	4 30 W.	Sill. Jour., 1838; also Regents' Report of 1839.
7	1838, July 6	4 30 W.	At Guilford, in $\phi = 42° 24'$, $\lambda = 75° 26'$; Regents' Report; Sill. Jour., 1838; when referred to Oxford, 4° 27′ W.
8	1849, November 27	5 11 W.	E. B. W. Call, as above.
9	1857, April 4	5 44 W.	
10	1858, February 4	5 47 W.	
11	1858, December	5 50 W.	
12	1873, December 1	6 52 W.	Erwing Taintor, local surveyor (azimuth determined from observations of Polaris).
13	1874, May 29, 30, June 2, 3, 4, 5, 6.	6 55.7 W.	Dr. T. C. Hilgard, observer for United States Coast Survey, on hill about three-fourths of a mile north of railroad-depot; MS. in Coast Survey archives.

Collection of Magnetic Declinations, etc.—Continued.

BUFFALO, N. Y.

$\phi = 42^\circ 52'.8$ $\lambda = 78^\circ 53'.5$ W. of Gr.

(Light-house in the harbor.)

		° ′		
1	1797	0 00		Amry Atwater, surveyor, east end of Lake Erie; MS. collection by Charles Whittlesey, communicated to the Coast Survey March 26, 1860.
2	1837	1 25	W.	R. W. Haskins, $\phi = 42^\circ 53'$, $\lambda = 78^\circ 55'$; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
3	1839	1 15	W.	At Fort Erie, $\phi = 42^\circ 54'$, $\lambda = 78^\circ 59'$; United States Lake Survey chart.
4	1845	1 25	W.	Captain Lefroy, Gen. Sir E. Sabine's Cont., xiii, in Phil. Trans. Roy. Soc., 1872.
5	1859, June	2 56.5	W.	Lieut. W. P. Smith, United States Lake Survey, $\phi = 42^\circ 53'$, $\lambda = 78^\circ 55'$, near south pier; Report of the United States Lake Survey by Captain Meade, Appendix B, Detroit, 1859.
6	1872, June 14	3 52.4	W.	Capt. A. N. Lee, United States Lake Survey, $\phi = 42^\circ 53'$, $\lambda = 78^\circ 58'$; magnetic results, 1870–'73, Report of the Chief of Engineers for 1873, pp. 1195, 1197.
7	1873, June 3, 13	3 58.3	W.	

ERIE PA.

$\phi = 42^\circ 07'.8$ $\lambda = 80^\circ 05'.4$ W. of Gr.

(Court-house.)

		° ′		
1	1795	0 43	E.	Andrew Ellicott, in $\phi = 42^\circ 08'.2$, $\lambda = 80^\circ 05'.2$, stone monument corner of Parade and Front streets; American Almanac of 1861, p. 54.
2	1841, August 9	0 30	W.	Prof. A. D. Bache, magnetic survey of Pennsylvania; Coast Survey Report of 1862, p. 213.
3	1862, August 6, 7	1 33	W.	C. A. Schott, assistant Coast Survey, same place as above, near Mr. Reed's house, Seventh street, $\phi = 42^\circ 07'.5$, $\lambda = 80^\circ 05'.3$; Coast Survey Report for 1862, p. 212.
4	1873, June 11, 12	2 00.7	W.	Capt. A. N. Lee, United States Lake Survey, in $\phi = 42^\circ 08'.2$, $\lambda = 80^\circ 05'.3$; magnetic results, 1870–73, Report of Chief of Engineers for 1873, pp. 1195, 1197.

Collection of Magnetic Declinations, etc.—Continued.

CLEVELAND, OHIO.

$\phi = 41° 30'.3$ $\lambda = 81° 42'.0$ W. of Gr.

		° ′		
1	1796, September	2 00	E.	Aug. Porter and Seth Pease, in $\phi = 41° 30'$, $\lambda = 81° 40'$; MS. compiled by Charles Whittlesey, March, 1860, Coast Survey archives.
2	1830	1 20	E.	Ahaz Merchant; Prof. E. Loomis' collection, Sill. Jour., vol. xxxix, 1840.
3	1831, August	1 15	E.	Edwin Foote; MS. compiled by Charles Whittlesey, 1860.
4	1834 (winter)	0 50	E.	Ahaz Merchant; Prof. E. Loomis' collection, as above.
5	1838 (winter)	0 35	E.	Ahaz Merchant; reference as above.
	1840	1 19	E.	Prof. E. Loomis; Phil. Trans. Roy. Soc., 1872, General Sabine's Cont., xiii. [Not used.]
6	1841, May 1	0 05.2	E.	J. N. Pillsbury; MS. compiled by Charles Whittlesey, 1860.
7	1845	0 39	E.	From a chart of survey of North and Northwest Lakes, Topographical Engineers; beacon-light, in $\phi = 41° 31'$, $\lambda = 81° 41'.5$.
8	1859, July	0 46	W.	Lieut. W. P. Smith, Topographical Engineers, in $\phi = 41° 30'$, $\lambda = 81° 43'$; MS. by Charles Whittlesey, also MS. by W. F. Raynolds, major of Engineers, Survey of North and Northwest Lakes.
	1865	1 12	E.(?)	MS. (December, 1865) by W. F. Raynolds, major of Engineers, as above. [Value not used.]
9	1871, November 9–11	0 32.6	W.	E. Goodfellow, assistant Coast Survey; Coast Survey archives; at Marine Hospital, in $\phi = 41° 30'.4$, $\lambda = 81° 41'.5$.
10	1872, June 17, 18	0 44.9	W.	Capt. A. N. Lee, United States Lake Survey; Report of Chief of Engineers for 1873.
11	1873, June 16, 17	0 50.9	W.	Capt. A. N. Lee, United States Lake Survey; reference as above.

DETROIT, MICH.

$\phi = 42° 20'.0$ $\lambda = 83° 03'.0$ W. of Gr.

		° ′		
1	1810	2 48	E.	J. Mansfield; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838. Position assigned, $\phi = 42° 30'$, $\lambda = 82° 58'$.
2	1822	3 13	E.	L. Lyon } Prof. E. Loomis' collection, in Sill. Jour., vol. xxxix, 1840. Position assigned, $\phi = 42° 24'$, $\lambda = 82° 58'$.
3	1828	2 50	E.	L. Lyon }
4	1835	2 10	E.	Geological Report }
5 {	1840	2 00	E.	Geological Report }
5 {	1840	1 56	E.	Prof. E. Loomis; Gen. Sir E. Sabine, Phil. Trans. Roy. Soc., 1872, Contributions, No. xiii.
6	1859	0 42	E. }	United States Lake Survey, MS. communicated by Col. W. F. Raynolds, United States Engineers. Position, $\phi = 42° 20'$, $\lambda = 83° 03'$.
7	1865	0 40	E. }	
8	1872, May 8–29	0 25.2	E. }	United States Lake Survey, Gen. C. B. Comstock, U. S. A., superintendent; Report of the Chief of Engineers for 1873, pp. 1195–1197; Capt. A. N. Lee, U. S. A., observer. Position assigned, $\phi = 42° 20'.0$, $\lambda = 83° 02'.5$.
9	1873, May 5–17	0 17.3	E. }	

Collection of Magnetic Declinations, etc.—Continued.

NEW YORK, N. Y., AND VICINITY.

$\phi = 40° 42'.7$ $\lambda = 74° 00'.4$ W. of Gr.

(New York City Hall.)

No.	Date	° ′	Authority
	1609, September 2	8 W.	Hudson, on his third voyage, near the Jersey shore, a little below the mouth of Hudson River. The day before he found not above 2° W. [See reference below.]
	1609, September 13	13 W.	Hudson, on his third voyage, a few miles up the Hudson River. This observation may have been made on shore. Prof. E. Loomis' collection, in Sill. Jour., vol. xxxix, 1840; extract furnished by Prof. J. Sparks from 3d vol. of Purchas' Pilgrims. [Observation not used.]
1	1686	8 45 W.	Mr. Welles; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838.
2	1691	8 45 W.	On Staten Island; Geological Survey of New York, 1858, E. Duxbury's patent.
3	1723	7 20 W.	G. Burnet } Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838.
4	1750	6 22 W.	Mr. Alexander
5	1755	5 00 W.	Mr. Evans
	1775	7 W.	J. F. W. Des Barres' Atlantic Neptune, London, 1781, at Sandy Hook, New York Bay. [Not used.]
6	1789	4 20 W.	Professor Loomis' collection of 1838; also Encyc. Met., 1848.
7	1824	4 40 W.	Blunt's map; Prof. E. Loomis' collection of 1838.
8	1834	4 50 W.	Captain Owen; Prof. E. Loomis' collection of 1838.
9	1837	5 40 W.	Prof. J. Renwick, Columbia College; Prof. E. Loomis' collection of 1838.
10	1840, June 16 to July 11	5 01 W.	Lieut. S. C. Rowan, U. S. N., for United States Coast Survey, at Howard, Staten Island, in $\phi = 40° 37'.6$, $\lambda = 74° 05'.4$; MS. in Coast Survey archives.
	1840, July 18 to October 16	5 53 W.	Lieut. S. C. Rowan, U. S. N., for United States Coast Survey, at Bergen Neck, in $\phi = 40° 45'.8$, $\lambda = 74° 02'.6$; MS. in Coast Survey archives.
11	1841	6 06 W.	Douglass' map of New Jersey; Coast Survey archives.
	1842, September	5 32.5 W.	Coast Survey determination (observer not stated) at Sandy Hook, in $\phi = 40° 27'.7$, $\lambda = 74° 00'.2$; MS. in Coast Survey archives.
	1844, January	5 51.1 W.	Lieut's. G. M. Bache and J. Hall, U. S. N., for United States Coast Survey, at Sandy Hook (same place as in 1842); MS. in Coast Survey archives.
	1844, August 20-22	5 51.0 W.	Prof. J. Renwick, for United States Coast Survey, at Sandy Hook, in $\phi = 40° 27'.7$, $\lambda = 74° 00'.2$; Coast Survey Report for 1854, p. 144*.
12	1844, August 24	6 13.1 W.	Prof. J. Renwick, for United States Coast Survey, at Columbia College, in $\phi = 49° 42'.7$, $\lambda = 74° 00'.5$ (old position); reference as above.
13	1845, September 4	6 25.3 W.	Prof. J. Renwick, for United States Coast Survey, at Columbia College; reference as above.
14	1846, April 30	5 09.7 W.	Dr. J. Locke, for United States Coast Survey, at Bloomingdale Asylum, in $\phi = 40° 50'.3$, $\lambda = 73° 56'.7$; Coast Survey Report for 1854, p. 144*.
	1846, May 4	5 54.7 W.	Dr. J. Locke, for United States Coast Survey, at Mount Prospect (formerly Flatbush), Brooklyn, in $\phi = 40° 40'.3$, $\lambda = 73° 58'.0$; reference as above. Other observations at this place are given in the Regents' Report of the University of the State of New York, viz: Oct., 1834, 4° 25′ W. | Dec. 22, 1840, 5° 00′ W. Oct., 1835, 4 45 | Dec. 30, 1841, 5 12 Oct., 1837, 4 45 | Dec. 30, 1842, 5 10 Dec. 18, 1838, 4 45 | Dec. 20, 1847, 5 30 Jan. 4, 1840, 4 55 | Oct. 26, 1848, 5 15 Assigned position $\phi = 40° 37'$, $\lambda = 73° 58'$.
	1846, May 14	35.1 W.	Dr. J. Locke, for United States Coast Survey, at Newark, in $\phi = 40° 44'.8$, $\lambda = 74° 07'.3$; Coast Survey Report for 1854, p. 144*.

Collection of Magnetic Declinations, etc.—Continued.

NEW YORK, N. Y., AND VICINITY—Continued.

$\phi = 40° 42'.7$ $\lambda = 74° 00'.4$ W. of Gr.

(New York City Hall.)

		° ′	
15	1847, October 16, 20	5 41.0 W.	R. H. Fauntleroy, assistant Coast Survey, at Leggot, in $\phi = 40° 48'.9$, $\lambda = 73° 53'.4$; reference as above.
16	1855, August 7	6 39.6 W.	C. A. Schott, assistant Coast Survey, at Governor's Island, in $\phi = 40° 41'.5$, $\lambda = 74° 01'.0$; Coast Survey Report for 1855, p. 337.
	1855, August 8	7 02.1 W.	C. A. Schott, at Bedloe's Island, in $\phi = 40° 41'.4$, $\lambda = 74° 02'.7$; reference as above.
	1855, August 11	6 28.0 W.	C. A. Schott, at Receiving Reservoir (now in Central Park), in $\phi = 40° 46'.7$, $\lambda = 73° 58'.2$; reference as above.
	1855, August 14	6 11.2 W.	C. A. Schott, at Sandy Hook; position same as in 1844; reference as above.
17	1860, September 21, 22	6 44.0 W.	C. A. Schott, at site of Mount Prospect, now Brooklyn (new) water-works, in $\phi = 40° 40'.3$, $\lambda = 73° 58'.0$; Coast Survey Report for 1860, p. 352.
	1872, October 31, November 1 and 2.	8 45.8 W.	A. H. Scott, United States Coast Survey, at Central Park, west of Mall, in $\phi = 40° 46'.2$, $\lambda = 73° 58'.2$; MS. in Coast Survey archives. [Not used.]
18	1873, November 5, 6, 7, 9	7 09.0 W.	Dr. T. C. Hilgard, observer for United States Coast Survey, at Sandy Hook; station as in 1844; MS. in Coast Survey archives.

HATBOROUGH, MORELAND TOWNSHIP, MONTGOMERY COUNTY, PA.

$\phi = 40° 12'$ $\lambda = 75° 07'$ W. of Gr.

		°	′		
1	1680	8	28	W.	Table communicated to the Superintendent of the Coast Survey in a letter, by Mr. E. W. Beans, dated Hatboro', March 1, 1852 (see Coast Survey Report for 1855, p. 312). [It is not to be presumed that this table presents direct observations, as the regularity of decennial values sufficiently attests; but it is not doubted that it rests upon *reliable* observations of numerous bearings of old (and new) lines which were submitted to some process of interpolation, probably graphical.—Sch.]
2	1690	8	15	W.	
3	1700	7	55	W.	
4	1710	7	28	W.	
5	1720	7	00	W.	
6	1730	6	25	W.	
7	1740	5	35	W.	
8	1750	4	55	W.	
9	1760	4	00	W.	
10	1770	2	55	W.	
11	1780	2	05	W.	
12	1790	1	50	W.	
13	1800	1	55	W.	
14	1810	2	00	W.	
15	1820	2	27	W.	
16	1830	3	00	W.	
17	1840	3	50	W.	
18	1850	4	25	W.	

Collection of Magnetic Declinations, etc.—**Continued.**

PHILADELPHIA, PA.

$\phi = 39° 56'.9$ $\lambda = 75° 09'.0$ W. of Gr.

(State-house.)

		°	′		
1	1701	8	30	W.	By Mr. Scull, as stated by G. Gillet, Sill. Jour., vol. xxiii, 1833. [See also Coast Survey Report for 1855, pp. 313, 314.]
2	1710	8	30	W.	Th. Whitney; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838.
3	1750	5	45	W.	Kalm's Travels; reference as above.
4	1793	1	30	W.	Th. Whitney; reference as above.
	1793	1	30	W.	By Mr. Brooks; Sill. Jour., vol. xxiii, 1833.
5	1802	1	30	W.	By Mr. Howell; reference as above.
6	1804	2	00	W.	By several men of science; reference as above.
	1804	2	10	W.	Th. Whitney; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
7	1813	2	25	W.	D. McClure; reference as above.
	1813	2	27	W.	By Mr. Whitney; Sill. Jour., vol. xxiii, 1833.
8	1837	3	52	W.	W. R. Johnson; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
9	1840, June	3	37	W.	Dr. A. D. Bache, at Girard College, $\phi = 39° 58'.4$, $\lambda = 75° 10'.2$; annual change from *differential observations* between 1840, June, and 1845, December, $= 4'.4$ (Coast Survey Reports for 1859, p. 285, and 1860, p. 311); subtracting $5'.3$ from his observation, $3° 53'.7$ July 20 and November 1, we find $3° 48'$ for June, 1840; again subtracting $26'$ from Dr. Locke's observation, $3° 51'.1$ in May, 1846, we find $3° 25'$; mean adopted, $3° 37'$.†
10	1841, July 20 and November 1.	3	53.7	W.	Dr. A. D. Bache, at Girard College; magnetic survey of Pennsylvania; Coast Survey Report for 1862, p. 213.
11	1846, May 23	3	51.1	W.	Dr. J. Locke, Girard College magnetical observatory; Coast Survey Report for 1854, p. 144*.
12	1855, September 5	4	31.7	W.	C. A. Schott, assistant Coast Survey, near site of magnetical observatory, Girard College; Coast Survey Report for 1855, p. 337.
13	1862, August 15, 16	5	00.0	W.	C. A. Schott, assistant Coast Survey, at site of magnetical observatory, Girard College; Coast Survey Report for 1862, p. 212.
14	1872, October 19, 20, 21	5	27.8	W.	A. H. Scott, United States Coast Survey, at site of magnetical observatory, Girard College; MS. in Coast Survey archives.

† Which is preferred to the values given in Coast Survey Report for 1864, p. 204.—Sch.

Collection of Magnetic Declinations, etc.—Continued.

WASHINGTON, D. C.

$\phi = 38° 53'.3$ $\lambda = 77° 00'.6$ W. of Gr.

(United States Capitol.)

		° ′		
	1792	0 51	E.	Major A. Ellicott, surveyor-general; inscription on fourth mile-stone northwesterly from east corner of District; reported by G. Mathiot. [Supposed affected by local deviation; not used.]
1	1792	0 19	E.	A. Ellicott; inscription on first mile-stone northwesterly from east corner of District; reported by J. Wiessner.
	1792	0 10	E.	A. Ellicott; inscription on east corner-stone, District; reported by J. Wiessner.
2	1809, December	0 52	W.	N. King; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
3	1841.0	1 20.2	W.	J. M. Gilliss, U. S. N.; Capitol Hill, north of Capitol; Sen. Doc., 2d ses., 28th Cong., 1844–45.
4	1842.0	1 23.9	W.	J. M. Gilliss, U. S. N.; reference as above.
5	1855, July	2 21	W.	C. A. Schott, assistant Coast Survey; Coast Survey Report for 1855, p. 334, on Capitol Hill, near Gilliss station.
6	1856, August 14, 20	2 21.4	W.	C. A. Schott, at (old) Coast Survey Office, Capitol Hill; also 2° 01′ W., August 15, in park east of the Capitol; Coast Survey Report for 1856, p. 227.
7	1857, March 9	2 24.8	W.	W. Read; near Capitol, south side; Coast Survey Report for 1858, p. 196. Communicated by observer.
8	1860, August 16 to September 26.	2 26.7	W.	C. A. Schott, at (old) Coast Survey Office; $\phi = 38° 53'.1$, $\lambda = 77° 00'.5$; Coast Survey Report for 1860, p. 352.
9	1862, August 18, 19	2 39.4	W.	C. A. Schott, at (old) Coast Survey Office; Coast Survey Report for 1862, p. 212.
10	1863, June 18 to July 28	2 41.8	W.	C. A. Schott, at (old) Coast Survey Office; Coast Survey Report for 1863, p. 204.
11	1866, November 1	2 44.2	W.	Prof. W. Harkness, U. S. N.; United States Naval Observatory grounds, in $\phi = 38° 53'.7$, $\lambda = 77° 03'.1$; Smithsonian Contributions to Knowledge, No. 239, p. 61, Washington, 1873.
12	1867, January to December	2 48.1	W.	C. A. Schott, at magnetic observatory, cor. Second street east and C street south, Capitol Hill, in $\phi = 38° 53'.1$, $\lambda = 77° 00'.2$; Monthly Determinations, Coast Survey Report for 1869, pp. 199–207.
13	1868, January to December	2 51.2	W.	
14	1869, January to June, inclusive.	2 53.0	W.	
15	1870, June 13, 14, 15	2 53.6	W.	C. A. Schott, at magnetic observatory, corner Second and C streets southeast; Coast Survey Report for 1870, Appendix No. 14.
16	1871, June 14, 15, 16	2 56.9	W.	
17	1872, June 14, 15, 17	3 00.0	W.	
18	1873, June 14, 16, 17	3 00.1	W.	Observer and locality as before; MS. in Coast Survey archives.
19	1874, June 13, 15, 16	3 07.4	W.	
	1874, July 20, 21, 22	3 05.2	W.	

CAPE HENRY, VA.

$\phi = 36° 55'.5$ $\lambda = 76° 00'.5$ W. of Gr.

(Light-house, 1857.)

		° ′		
1	1732	4 42	W.	W. Hoxton, seven miles from Cape Henry, in $\phi = 36° 50'$; Hansteen's Magnetismus der Erde, 1819.
	1732	4 40	W.	Douglass' History, in $\phi = 37° 07'$, $\lambda = 75° 30'$; Prof. E. Loomis' collection, in Sill. Jour., vol xxxiv, 1838.
	1775	5 00	W.	J. F. W. Des Barres' Atlantic Neptune, London, 1781. [Not used.]
	1823–24	1 32	W.	State map of Virginia, of 1859, by H. Boye. [Not used.]
2	1832, June 9, 11	0 45	W.	Prof. J. N. Nicollet; Coast Survey Report for 1864, p. 210.
3	1856, September 11, 12	1 28	W.	C. A. Schott, assistant Coast Survey, in $\phi = 36° 55'.6$, $\lambda = 76° 00'.4$; Coast Survey Report for 1856, p. 227.

Collection of Magnetic Declinations, etc.—Continued.

CHARLESTON, S. C.

$\phi = 32°\ 46'.6 \qquad \lambda = 79°\ 55'.8$ W. of Gr.

(St. Michael's Church.)

		° ′	
	1742	5 23 E.	English Pilot, published on Tower Hill in 1794; extracted from a paper by Andrew Hughes. [Not used.]
1	1775	3 48 E.	Des Barres' Atlantic Neptune, London, 1781.
	1777	3 48 E.	From a chart; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838, probably the same as that given in the Neptune. [Not used.]
2	1784, February	5 15 E.	Joseph Purchell, surveyor; see pamphlet by Charles Parker, Charleston, 1849. [Observation said to come from a reliable source.]
3	1785, October	5 45 E.	
4	1824-25	3 45 E.	Lieutenant Sherburne, U. S. N.; Blunt's chart of 1824-25.
5	1837	2 54 E.	Captain Missroom; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838. Position $\phi = 32°\ 47'$, $\lambda = 79°\ 57'$.
6	1841, May	2 24 E.	Barnet; Phil. Trans. Roy. Soc., vol. for 1849.
7	1847, October	2 15 E.	Charles Parker; see his pamphlet (Charleston, 1849).
8	1849, April 1 and 22	2 16.5 E.	C. O. Boutelle, assistant Coast Survey, at Breach Inlet, in $\phi = 32°\ 46'.3$, $\lambda = 79°\ 48'.9$, Sullivan's Island; Coast Survey Report for 1854, p. *145.
9	1874, May 27, 28, 29	0 58.1 E.	C. O. Boutelle, assistant Coast Survey, at Fort Marshall, same position as for Breach Inlet; MS. in Coast Survey archives.

SAVANNAH, GA.

$\phi = 32°\ 04'.9 \qquad \lambda = 81°\ 05'.5$ W. of Gr.

(Savannah Exchange.)

		° ′	
1	1817	4 E.	Becquerel's Traité du Magnétisme, Paris, 1846; Cartes du Dépôt, in $\phi = 32°\ 04'$, $\lambda = 80°\ 40'$.
2	1838	5 05 E.	Geological survey, in $\phi = 32°\ 05'$, $\lambda = 81°\ 07'$; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxix, 1840.
	1839	3 31 E.	Dr. Posey; reference as above.
3	1852, April 26-28	3 40.3 E.	J. E. Hilgard, assistant Coast Survey, in $\phi = 32°\ 05'.0$, $\lambda = 81°\ 05'.1$, on Hutchinson's Island; Coast Survey Report for 1854, p. *145.
4	1857, May 1 and 2	3 27.5 E.	C. A. Schott, assistant Coast Survey; position as above; Coast Survey Report for 1858, p. 192.
5	1874, March 8, 9, 10	1 58.5 E.	F. Blake and C. Tappan, United States Coast Survey; position on Hutchinson's Island, opposite Savannah, as above; MS. in Coast Survey archives.

Collection of Magnetic Declinations, etc.—Continued.

KEY WEST, FLA.

$\phi = 24° 33'.5$ $\lambda = 81° 48'.5$ W. of Gr.

(Tift's observatory.)

		° ′	
1	1829, February	6 25 E.	W. A. Whitehead; from a map of Florida, by the Topographical Engineers, of 1846.
2	1843	6 02 E.	Report of Commander L. M. Powell, U. S. N., at custom-house.
3	1849, August 19–21	5 28.8 E.	J. E. Hilgard, assistant Coast Survey, at Sand Key, in $\phi = 24° 27'.2$, $\lambda = 81° 53'.1$; Coast Survey Report for 1854, p. *145.
4	1860, February, March, June, and December.	4 46.6 E.	Prof. W. P. Trowbridge, assistant United States Coast Survey; subsequent observer, S. Walker; Coast Survey Report for 1860, p. 340.
5	1861, February, March, April.	4 44.5 E.	Observer, S. Walker.
6	1862, monthly, May to December.	4 39.9 E.	Observer, S. Walker.
7	1863, monthly, January to December.	4 36.8 E.	Observer, S. Walker.
8	1864, monthly, January to December.	4 33.9 E.	Observer, S. Walker.
9	1865, monthly, January to December.	4 31.5 E.	Observer, S. Walker.
10	1866, January to April, inclusive.	4 29.8 E.	Observer, S. Walker. The above observations between 1860 and 1866 inclusive were taken at the Coast Survey magnetic observatory at Key West, in $\phi = 24° 33'.1$, $\lambda = 81° 48'.5$. The results are corrected for daily variation.

HAVANA, CUBA.

$\phi = 23° 08'$ $\lambda = 82° 22'$ W. of Gr.

		° ′	
1	1726	4 24 E.	Mathews, in $\phi = 23° 02'$, $\lambda = 81° 44'$; Encyc. Metrop., 1848.
2	1732, March and April	4 30 E.	J. Harris, off Havana, in $\phi = 23° 08'$, $\lambda = 82° 32'$; Phil. Trans. Roy. Soc., vol. vii (abridged), 1724–34; also Encyc. Metrop., 1848.
3	1815	7 00 E.	Encyc. Brit., 7th edition, 1842.
4	1816, August	5 30 E.	Bentley, Encyc. Brit., 7th edition.
5	1857, January 28	5 15 E.	Karl Friesach; Imp. Acad. of Sci., Vienna, vol. xxix, 1858.
6	1858	5 45 E.	From a map of Cuba, 1860. [The Morro light is in $\phi = 23° 09'.3$, $\lambda = 82° 21'.4$.]

Collection of Magnetic Declinations, etc.—Continued.

KINGSTON, PORT ROYAL, JAMAICA.

$\phi = 17° 55'$ $\lambda = 76° 50'$. W of Gr.

		° ′		
	1660	6 30	E.	In Jamaica, according to J. Robertson; Phil. Trans. Roy. Soc., 1806. [Not used.]
	1700	6 30	E.	According to Mountain's chart, constructed in the year 1700 from Dr. Halley's tables; Long's History of Jamaica; E. Halley's chart for 1700 gives 7° E.; Greenwich observations for 1869. [Not used.]
1	1732, March and April	6 ? to 6 05	E.	At Black River; J. Harris; Phil. Trans. Roy. Soc., 1733.
2	1789 to 1793	6 50	E.	J. Leard; chart of Port Royal.
	1791 to 1792	6 45	E.	
3	1806	6 30	E.	J. Robertson; Phil. Trans. Roy. Soc., 1806. Variation in Jamaica said to have been constant for 130 or 140 years.
4	1819	4 50	E.	De Mackau, in $\phi = 17° 55'$, $\lambda = 76° 09'$; Becquerel's Traité du Magnétisme, Paris, 1846.
	1821	4 50	E.	De Mayne, in $\phi = 17° 55'$, $\lambda = 76° 53'$; Becquerel, as above.
5	1822	4 54	E.	Owen; Becquerel, as above.
6	1832	5 13	E.	Foster; Becquerel, as above.
7	1833 (?)	4 30	E.	From a map of Kingston of 1854.
8	1837, October	4 18	E.	Milne, in $\phi = 17° 56'$, $\lambda = 76° 51'$; Contributions to Terr. Mag., No. ix, by Lieut. Col. E. Sabine, Phil. Trans. Roy. Soc., 1849, part ii.
9	1847, April	3 40	E.	Barnett, in $\phi = 17° 56'$, $\lambda = 76° 51'$; Contributions to Terr. Mag., No. ix, by Lieut. Col. E. Sabine, Phil. Trans. Roy. Soc., 1849, part ii.
10	1857, March 2	3 40	E.	Karl Friesach; Imp. Acad. of Sci., Vienna, vol. xxix, 1858.
11	1866	4 57	E.	English Admiralty Chart of Jamaica, No. 446. Variation in 1866 nearly stationary.

NEW ORLEANS, LA.

$\phi = 29° 57'.2$ $\lambda = 90° 03'.9$ W. of Gr.

(Custom-house.)

		° ′		
1	1720	2	E.	Father Laval; Prof. E. Loomis' collection; Sill. Jour., vol. xxxiv, 1838.
2	1768	7 50	E.	Gauld; Gauld's Survey of the Delta; 10′ added to declination at Pass à Loutre to refer to New Orleans.
3	1796	5 06	E.	A. G. Blanchard, city surveyor; change 2° E. from 1796 to 1870.
4	1806	8 03	E.	Lason; from 372 observations; Prof. E. Loomis' collection. Sill. Jour., vol. xxxiv, 1838.
5	1810	8 20	E.	From information in General Land-Office.
6	1856, December 28	8 00	E.	Karl Friesach; Berichte der Kais. Acad., Vienna, vol. xxix, 1858.
7	1858, April 6, 7	7 51.5	E.	G. W. Dean, assistant United States Coast Survey; near Canal and Basin streets, $\phi = 29° 57'.4$, $\lambda = 90° 04'.4$; Coast Survey Report of 1858, p. 192.
8	1870	7 06	E.	M. J. Thompson, State engineer.
9	1872, February	6 59.3	E.	Dr. T. C. Hilgard, observer; Bache-Fund Magnetic Survey; MS. communication.

VERA CRUZ, MEXICO.

$\phi = 19° 12'$ $\lambda = 96° 09'$ W. of Gr.

		° ′		
1	1726 to 1727	2 15	E.	Joseph Harris; Phil. Trans. Roy. Soc. (abridged), 1824–34.
2	1769	6 40	E.	Encyc. Brit., 7th edition, 1842.
	1769, March 15	6 28	E.	
3	1776	7 30	E.	Don Ulloa; Encyc. Brit., 7th edition.
4	1815	10 37	E.	Malony; Encyc. Brit., 7th edition.
5	1819, April 27	9 16	E.	Wise; Encyc. Brit., 7th edition.
6	1856, August 7 and 8	8 17	E.	August Sonntag, in $\phi = 19° 12'$, $\lambda = 96° 09'$; Smithsonian Contributions to Knowledge, Washington, 1860; also Coast Survey Report of 1856, p. 214.
7	1861	8 20	E.	English Admiralty Chart, No. 523, corrected to 1861.

Collection of Magnetic Declinations, etc.—Continued.

CITY OF MEXICO, MEXICO.

$\phi = 19° 25'.9$ $\lambda = 99° 06'.0$ W. of Gr.

		°	′		
1	1769, June	5	20	E.	Don Alzate; Hansteen's Magnetismus der Erde, 1819.
2	1769, December	5	35	E.	Don Alzate; reference as above.
3	1803, December	8	08	E.	Alex. von Humboldt; reference as above.
4	1850	8	35.2	E.	Velasquez y Terán; F. Diaz Covarrubias, Tratado de Topografia y Geodesia, México, 1869, tomo 1, p. 221.
5	1856, December 10–17	8	46	E.	Aug. Sonntag; Observations on Terr. Mag. in Mexico, Smithsonian Contributions to Knowledge, Washington, 1860; also Coast Survey Report of 1856, p. 214.
6	1858	8	22.3	E.	Alamazan; F. Diaz Covarrubias' Tratado, as above.
7	1860	8	30	E.	Salazar Ilarregui; Tratado, as above.
8	1862	8	20.5	E.	Diaz Covarrubias; Tratado, as above.
9	1866	8	08.5	E.	Ponce de Leon; Tratado, as above.
10	1867	8	09.3	E.	
11	1868	8	10.0	E.	Fernandéz y Diaz Covarrubias; Tratado, as above.

ACAPULCO, MEXICO.

$\phi = 16° 50'.5$ $\lambda = 99° 52'.3$ W. of Gr.

(South of Fort San Diego.)

		°	′		
1	1744	3		E.	Anson; Hansteen's Magnetismus der Erde, 1819.
2	1791, April 29	7	44	E.	Don A. Malaspina, observed on land; Berliner Astronomisches Jahrbuch, vol. 53, for 1828.
3	1822	8	40	E.	Hall; in $\phi = 16° 50$, $\lambda = 99° 51'$; Becquerel's Traité du Magnétisme, Paris, 1846.
4	1828	9	07	E.	Beechey; Becquerel, as above.
5	1837	8	23	E.	Sir E. Belcher, San Diego Fort, in $\phi = 16° 50'.9$, $\lambda = 99° 52'.2$; Admiralty Chart of Acapulco.
	1838	8	13	E.	Sir E. Belcher; Phil. Trans. Roy. Soc., 1843.
	1838	8	17	E.	Du Petit Thouars; Voyage of the Frigate Venus.
	1841	8	17	E.	Duflot de Mofras' Exploration of Oregon. Paris, 1844. [Probably Du Petit Thouars' values; not used.]
6	1866, May 30	8	22	E.	Prof. W. Harkness, U. S. N., in $\phi = 16° 50'.1$, $\lambda = 99° 52'.3$; Observations on Terr. Mag., Smithsonian Contributions to Knowledge, No. 239, 1873, p. 61.

PANAMA, NEW GRANADA.

$\phi = 8° 55'$ $\lambda = 79° 30'$ W. of Gr.

(Flamenco Island.)

		°	′		
1	1775, November	7	49	E.	Encyc. Brit., 7th edition, 1842.
2	1790, October 3	7	49	E.	Don A. Malaspina; Berliner Ast. Jahrbuch, vol. 53, for 1828, p. 188.
	1791, December	7	49	E.	Encyc. Brit., 7th edition, 1842. [Probably same as preceding authority; not used.]
3	1802	8	00	E.	Encyc. Brit., 7th edition, 1842.
4	1822	7	00	E.	Hall, in $\phi = 8° 58'$, $\lambda = 79° 21'$; Becquerel's Traité du Magnétisme, Paris, 1846.
5	1837	7	02	E.	Sir E. Belcher, in $\phi = 8° 57'$, $\lambda = 79° 29'$; Phil. Trans. Roy. Soc., 1843.
6	1849	7	15	E.	Hughes, Brit. Admiralty Chart.
	1849	6	55	E.	Maj. W. H. Emory, Mexican Boundary Survey, in $\phi = 8° 57'$, $\lambda = 79° 29'$. See also Coast Survey report for 1856, p. 223.
7	1866, May 14	5	56	E.	Prof. W. Harkness, U. S. N., in $\phi = 8° 55'$, $\lambda = 79° 30'.5$; Smithsonian Contributions to Knowledge, No. 239, Washington, 1873.

Collection of Magnetic Declinations, etc.—Continued.

SAN BLAS, MEXICO.

$\phi = 21° 32'.6$ $\lambda = 105° 15'.7$ W. of Gr.

		°	′		
1	1791, April 12	7	28	E.	Don A. Malaspina, observed on shore; Berliner Ast. Jahrbuch, vol. 53, for 1828; also Encyc. Brit., 7th edition, 1842.
2	1821–22	8	40	E.	Hall; Encyc. Brit., 7th edition.
3	1828	11	06	E.	Beechey; Beechey's Voyage to the Pacific, 1825–28; also Becquerel's Traité du Magnétisme, Paris, 1846.
4	1837	8	34	E.	Sir E. Belcher; in $\phi = 21° 32'$, $\lambda = 105° 16'$; Phil. Trans. Roy. Soc., 1843.
5	1839	9	00	E.	Sir E. Belcher; Phil. Trans. Roy. Soc., 1843.
6	1841	9	12	E.	Duflot de Mofras' Exploration of Oregon, Paris, 1844.

SAN DIEGO, CAL.

$\phi = 32° 42'.1$ $\lambda = 117° 14'.3$ W. of Gr.

(La Playa, Point Loma.)

		°	′		
1	1792	11		E.	Vancouver; in $\phi = 32° 39'$, $\lambda = 117° 17'$; Capt. G. Vancouver's Voyage of Discovery, etc., 1790–95, vol. 2, p. 475, London, 1798; also Hansteen's Magnetismus der Erde, 1819.
	1793, December	11		E.	Reference as above; in $\phi = 32° 42'$, $\lambda = 116° 53'$. Observed on board ship on or near the coast. [Not used.]
2	1839	12	20.6	E.	Sir E. Belcher; in $\phi = 32° 41'$, $\lambda = 117° 13'$; Phil. Trans. Roy. Soc., 1841.
3	1841	11		E.	Duflot de Mofras, Exploration of Oregon, Paris, 1844; in $\phi = 32° 39'.5$, $\lambda = 117° 17'$.
4	1851, April 28 to May 7	12	28.8	E.	G. Davidson, assistant Coast Survey; near La Playa, in $\phi = 32° 42'.2$, $\lambda = 117° 14'.6$; Coast Survey Report of 1856, p. 229.
5	1853, October 15	12	31.7	E.	Lieut. W. P. Trowbridge, assistant Coast Survey; at La Playa, near the custom-house; Coast Survey Report of 1856.
6	1866, June 15	13	09.4	E.	Prof. W. Harkness, U. S. N.; in $\phi = 32° 42'$, $\lambda = 117° 13'$, at La Playa; Smithsonian Contributions to Knowledge, No. 239, Washington, 1873.
	1871, May 28–30	14	46.7	E.	G. Davidson, assistant Coast Survey; at New San Diego, in $\phi = 32° 43'.1$, $\lambda = 117° 09'.7$; MS. in Coast Survey archives. [Not used; distance from La Playa too great.]
7	1872, November 19–21	13	19.4	E.	G. Davidson and S. R. Throckmorton, United States Coast Survey; near La Playa, in $\phi = 32° 42'.2$, $\lambda = 117° 14'.6$, station of 1851; MS. in Coast Survey archives.

Collection of Magnetic Declinations, etc.—Continued.

MONTEREY AND POINT PINOS, CAL.

$\phi = 36° 36'.2$ $\lambda = 121° 53'.6$ W. of Gr.

(Custom-house.)

		° ′		
1	1791, September 23	10 56	E.	Don A. Malaspina; Berliner Ast. Jahrbuch, vol. 53, for 1828. Observation made on shore.*
	1792, December	12 22	E.	Vancouver, in $\phi = 36° 36'$, $\lambda = 121° 34'$; Capt. G. Vancouver's Voyage of Discovery, etc., 1790–95, vol. 2, p. 51, London, 1798; also Hansteen's Magnetismus der Erde, 1819. [Not used.]
2	1794, November 13	12 22	E.	Vancouver; in $\phi = 36° 36'$, $\lambda = 121° 51'$; Capt. G. Vancouver's Voyage of Discovery, etc., vol. iii, p. 337; also Hansteen's Magnetismus der Erde, 1819. Probably taken on shore.
3	1837	14 30	E.	Du Petit Thouars; Voyage of the Frigate Venus; near Monterey.
4	1839	14 13	E.	Sir E. Belcher, in $\phi = 36° 36'$, $\lambda = 121° 53'$; Phil. Trans. Roy. Soc., 1841.
5	1841	15 00	E.	Duflot de Mofras; Exploration of Oregon, Paris, 1844; at Presidio, Monterey, in $\phi = 36° 36'$, $\lambda = 121° 53'$.
6	1843	14 00	E.	Chart of the harbor of Monterey, surveyed by Commander T. A. Dornin; position of fort, $\phi = 36° 36'.4$, $\lambda = 121° 52'.4$.
7	1851, February 8	14 58.3	E.	G. Davidson, assistant Coast Survey; at Point Pinos astronomical station, $\phi = 36° 37'.8$, $\lambda = 121° 55'.5$; Coast Survey Report for 1856, p. 229.
8	1873, August 30, 31, September 1.	15 55.3	E.	G. Davidson and S. R. Throckmorton, United States Coast Survey; near astronomical station, in $\phi = 36° 37'.8$, $\lambda = 121° 55'.6$; MS. in Coast Survey archives.

* The Coast Survey Report for 1856, p. 229, gives the erroneous date 1790.

SAN FRANCISCO, CAL.

$\phi = 37° 47'.5$ $\lambda = 122° 27'.2$ W. of Gr.

(Presidio.)

		° ′		
1	1792, November 20	12 48	E.	Vancouver; in $\phi = 37° 48'$, $\lambda = 122° 08'$; Hansteen's Magnetismus der Erde, 1819. Probably on shore.
	1815, November 1	16 05	E.	Kotzebue's Voyage of Discovery, 1815–18; in $\phi = 37° 48'.6$, $\lambda = 122° 12'.5$. [Not used.]
·	1824	16 00	E.	Kotzebue. [Not used.] } Becquerel's Traité du Magnétisme, Paris, 1846.
2	1827	15 27	E.	Beechey } Becquerel's Traité du Magnétisme, Paris, 1846.
3	1829	15 06	E.	Erman } Becquerel's Traité du Magnétisme, Paris, 1846.
4	1837	15 20	E.	Sir E. Belcher; in $\phi = 37° 48'$, $\lambda = 122° 23'$; Phil. Trans. Roy. Soc., 1841.
	1837	15 00	E.	Du Petit Thouars; Voyage of the Frigate Venus.
5	1839	15 20	E.	Sir E. Belcher; in $\phi = 37° 48'$, $\lambda = 122° 23'$; Phil. Trans. Roy. Soc., 1841.
6	1841, October	15 30	E.	Duflot de Mofras, Exploration of Oregon, Paris, 1844; in $\phi = 37° 48'.5$, $\lambda = 122° 28'.4$.
	1842, January	15 30	E.	Duflot de Mofras, as above; at Fort Point.
7	1849–50	15 40.8	E.	Commander Ringgold, U. S. N., at Alcatraz Island, harbor of San Francisco.
8	1852, February 18–28	15 27.6	E.	G. Davidson, assistant Coast Survey; in $\phi = 37° 47'.5$, $\lambda = 122° 27'.2$, at Presidio; mean of daily maximum and minimum; Coast Survey Report, 1856, p. 229, and MS. in Coast Survey archives; mean 15° 28'.8 E.
	1852, March 24	15 28.8	E.	
	1852, April 21	15 27.8	E.	
	1852, May 28	15 31.1	E.	
9	1866, June 26	16 25.5	E.	Prof. W. Harkness, U. S. N.; in $\phi = 37° 49'$, $\lambda = 122° 21'$; east side of Yerba Buena Island; Smithsonian Contributions to Knowledge, No. 239, Washington, 1873.
	1871, December 14, 15, 16	16 23.1	E.(?)	G. Davidson and S. R. Throckmorton, United States Coast Survey; at Presidio station of 1852; MS. in Coast Survey archives. [Not used.]
10	1872, October 26, 27, 28	16 25.7	E.	Reference as above.
11	1873, June	16 25.9	E.	
	1873, August	16 24.2	E.	
	1873, November 12 to 16	16 26.2	E.	G. Davidson and W. Eimbeck, United States Coast Survey; at Presidio; MS. in Coast Survey archives.
12	1874, January 10–14	16 28.1	E.	Reference as above.

Collection of Magnetic Declinations, etc.—Continued.

CAPE DISAPPOINTMENT, COLUMBIA RIVER, OREGON.

$\phi = 46° 16'.7$ $\lambda = 124° 02'.0$ W. of Gr.

(South shore of Baker's Bay.)

		°	′		
1	1792, April 27	18		E.	Vancouver;* in $\phi = 46° 14'$, $\lambda = 123° 59'$, near mouth of Columbia River; Hansteen's Magnetismus der Erde, 1819.
	1792, December	20		E.	Vancouver's voyage;† reference as above; in $\phi = 46° 19'$, $\lambda = 123° 53'$. [Value evidently too high; not used.]
2	1839	19	11	E.	Sir E. Belcher; in $\phi = 46° 17'$, $\lambda = 124° 02'$; Phil. Trans. Roy. Soc., 1841; on Baker's Bay.
3	1842	20	00	E.	Duflot de Mofras, Exploration of Oregon, Paris, 1844; at mouth of Columbia River.
4	1851, July 5-9	20	19.1	E.	G. Davidson, assistant Coast Survey; in $\phi = 46° 16'.7$, $\lambda = 124° 02'.0$, near beach of Baker's Bay, Cape Disappointment; Coast Survey Report of 1856, p. 230.
	1851, July 14-19	20	45.3	E.	Reference as above; on top of cape, in $\phi = 46° 16'.6$, $\lambda = 124° 02'.0$, at astronomical station.
	1858	21	00	E.	Communication by S. Garfield, surveyor-general Washington Territory, dated August 24, 1866.
5	1873, October 24-27	21	26.5	E.	W. Eimbeck, United States Coast Survey; near beach of Baker's Bay, in $\phi = 46° 16'.7$, $\lambda = 124° 02'.0$; MS. in Coast Survey archives.
	1873, October 19-23	21	46.9	E.	W. Eimbeck, United States Coast Survey; at old astronomical station, top of cape; MS. in Coast Survey archives.

* Vancouver's observations made on board ship. † Observation by Broughton.

SITKA, ALASKA.

$\phi = 57° 02'.9$ $\lambda = 135° 19'.7$ W. of Gr.

(Parade grounds, Sitka.)

		°	′		
1	1804	26	45	E.	Lissiansky; Becquerel's Traité du Magnétisme, Paris, 1846; position, $\phi = 57° 03'$, $\lambda = 135° 30'$.
2	1824	27	30	E.	Kotzebue; reference as above.
3	1827.5	28	50	E.	General Sir E. Sabine's Contributions to Terr. Mag., No. xiii, Phil. Trans. Roy. Soc., 1872; position, $\phi = 57° 03'$, $\lambda = 135° 23'$.
4	1829	28	19	E.	Erman; Becquerel's Traité, as above.
5	1830.0	28	16	E.	General Sir E. Sabine's Contributions to Terr. Mag., No. xiii, as above.
6	1838.5	28	37	E.	Reference as above.
7	1839	29	32	E.	Sir E. Belcher; in $\phi = 57° 03'$, $\lambda = 135° 22'$; Phil. Trans. Roy. Soc., 1843.
8	1842.5	28	53	E.	General Sir E. Sabine's Contributions to Terr. Mag., No. xiii.
9	1851.0	29	14	E.	
10	1867, August 18-20	28	49	E.	A. T. Mosman, assistant, Coast Survey; at old Russian observatory on Japonski Island, harbor of Sitka; Coast Pilot of Alaska, United States Coast Survey, 1869, p. 120; assigned position, $\phi = 57° 02'.9$, $\lambda = 135° 20'.0$.

Collection of Magnetic Declinations, etc.—Continued.

CAPTAIN'S HARBOR, UNALASKA ISLANDS, ALEUTIAN ISLAND, ALASKA TERRITORY.

$\phi = 53° 52'.6$ $\lambda = 166° 31'.5$ W. of Gr.

(Greek church, Ilioulionk Village.)

		° ′	
1	1792	19 00 E.	Saritcheff; old chart; communicated by Dr. W. H. Dall, acting assistant Coast Survey November, 1873.
2	1806	19 24 E.	Kotzebue; Saritcheff's Atlas, Chart No. xv; in $\phi = 53° 55'$, $\lambda = 166° 43'$, at church of Ilioulionk Village; communicated by Dr. W. H. Dall, 1873.
3	1829.0	19 54 E.	Lütke; Unalaska Island, in $\phi = 53° 54'$, $\lambda = 166° 30'$; General Sir E. Sabine, Phil. Trans. Roy. Soc.; Contributions to Terr. Mag., No. xiii, 1872.
4	1848	19 30.5 E.	Chart No. 8, Russ. Hyd. Office, Captain's Harbor, $\phi = 53° 53'.7$, $\lambda = 166° 24'.0$; communicated by Dr. W. H. Dall, 1873.
5	1849	20 00 E.	Tebenkoff; Chart No. xxv; at church of Ilioulionk, $\phi = 53° 52'.0$, $\lambda = 166° 25'.0$.
6	1867, September 8, 9	19 47.4 E.	A. T. Mosman, assistant United States Coast Survey; at Captain's Harbor, $\phi = 53° 53'.9$, $\lambda = 166° 30'.4$; Assistant G. Davidson's expedition of 1867; MS. in Coast Survey archives.
7	1870	19 45 E.	Kadin; MS. chart, Captain's Harbor; communicated by Dr. W. H. Dall.
8	1873, May	18 59.7 E.	W. H. Dall, acting assistant Coast Survey; at church of Ilioulionk, in $\phi = 53° 52'.6$, $\lambda = 166° 31'.6$; MS. in Coast Survey archives.

The following magnetic declinations have not yet been incorporated in discussions:

EASTPORT, ME.

$\phi = 44° 54'.4$ $\lambda = 66° 59'.2$ W. of Gr.

(Fort Sullivan.)

		° ′		
1	1797	12 19 W.	From a chart; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838; at the mouth of St. Croix, in $\phi = 45° 05'$, $\lambda = 67° 12'$; reduction to Eastport about −5′.	
2	1857, September 16–19	15 21.1 W.	G. W. Dean, assistant Coast Survey; at Calais, in $\phi = 45° 11'.1$, $\lambda = 67° 16'.8$; Coast Survey Report for 1858, p. 191; reduction to Eastport −12′.	
3	1860, August to December	17 57.1 W.	G. B. Vose, observer for United States Coast Survey.	Coast Survey Report for 1865, Appendix No. 18; all observations made at Fort Sullivan.
4	1861, January to December	17 59.2 W.	G. B. Vose and S. Walker, observers for United States Coast Survey.	
5	1862, January to December	18 00.6 W.	S. Walker, R. H. Talcott, E. Goodfellow, observers for United States Coast Survey.	
6	1863, January to December	18 02.3 W.	E. Goodfellow, assistant, Coast Survey.	
7	1864, January to December	18 03.7 W.	E. Goodfellow, A. T. Mosman, and H. W. Richardson, observers for United States Coast Survey.	
8	1865, July 22, 23, 24, 25	18 06.1 W.	H. W. Richardson, observer for United States Coast Survey.	
9	1873, September 2, 3	18 56.0 W.	Dr. T. C. Hilgard, observer for United States Coast Survey; at Fort Sullivan; MS. in Coast Survey archives.	

HANOVER, N. H.

$\phi = 43° 42'$. $\lambda = 72° 18'$ W. of Gr.

(Dartmouth College.)

		° ′	
1	1765	7 00 W.	President Wheelock; in $\phi = 43° 41'$, $\lambda = 72° 10'$; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838.
2	1810	4 15 W.	
3	1839	9 15 W.	Prof. Young; in $\phi = 43° 42'$, $\lambda = 72° 10'$; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxix, 1840.
4	1873, October 4, 6, 9, 10, 11	10 49.6 W.	Dr. T. C. Hilgard, observer for United States Coast Survey; MS. in Coast Survey archives.

Collection of Magnetic Declinations, etc.—Continued.

CHESTERFIELD, N. H.*

$\phi = 42° 53'$ $\lambda = 72° 23'$ W. of Gr.

	°	'		
1812	6	26	W.	
1813	6	25	W.	
1814	6	17	W.	
1815	6	07	W.	
1816	6	03	W.	
1817	6	02	W.	
1818	6	00	W.	
1819	6	03	W.	
1820	6	00	W.	
1821	6	07	W.	
1822	6	12	W.	
1823	6	30	W.	
1824	6	40	W.	Nathan Wilde
1825	6	35	W.	
1826	6	35	W.	
1827	6	45	W.	
1828	6	52	W.	
1829	7	00	W.	
1830	7	06	W.	
1831	7	10	W.	
1832	7	15	W.	
1833	7	30	W.	
1834	7	35	W.	
1835	7	40	W.	
1836	7	45	W.	
1837	8	05	W.	A. C. Twining.

* From Prof. E. Loomis collection, in Sill. Jour., vol. xxxiv, 1838; position assigned, $\phi = 42° 53'$, $\lambda =$ 7

TORONTO, PROVINCE OF ONTARIO, CANADA.

$\phi = 43° 39'.4$ $\lambda = 79° 23'.4$ W. of Gr.

(Magnetical and Meteorological Observatory.*)

	°	'		
1841	1	14.3	W.	Vol. i, Toronto Observations, p. xi.
1842	1	18.9	W.†	
1845	1	29.1	W.	
1846	1	30.8	W.	
1847	1	33.2	W.	
1848	1	35.4	W.	Vol. ii, Toronto Observations, pp. iii-v.
1849	1	36.9	W.	
1850	1	38.6	W.	
1851	1	40.9	W.	
1853	1	46.1	W.	Observations in July and August... Corrected for annu secular variati
1854	1	48.0	W.	Observations in February, March, April, June.
1855	1	52.3	W.	Observations from August to December, both inclusive.
1856	1	56.3	W.	
1857	2	00.5	W.	
1858	2	04.5	W.	
1859	2	07.4	W.	
1860	2	10.6	W.	
1861	2	14.3	W.	
1862	2	15.7	W.	
1863	2	19.1	W.	
1864	2	21.9	W.	
1865	2	24.8	W.	
1866	2	27.6	W.	
1867	2	29.8	W.	
1868	2	33.2	W.	
1869	2	37.1	W.	Abstracts and results of magnetical and meteorological o
1870	2	41.9	W.	tions at the Magnetic Observatory, Toronto, Canada, fr
1871	2	47.9	W.	to 1871, inclusive. 1875.

* Results published by G. T. Kingston, M. A., director of the Magnetic Observatory, in the Canadian Journal, es munications, "Monthly absolute values of the magnetic elements at Toronto from 1856 to 1864 inclusive"; and "M of the magnetic elements at Toronto from 1865 to 1868 inclusive, with the annual means from 1841 to 1868".

† 1° 19'.1 in the publication of 1875.

Collection of Magnetic Declinations, etc.—Continued.

BALTIMORE, MD.

$\phi = 39° 17'.8$ $\lambda = 76° 37'.0$ W. of Gr.

(Washington Monument.)

		° ′	
1	1808	0 12.5 W.	D. Byrnes; from numerous observations in Baltimore in different localities; Sill. Jour., vol. xviii, 1830.
2	1840, August 27	2 16.5 W.	Dr. A. D. Bache; Coast Survey Report for 1862, p. 213.
3	1847, April 29	2 18.6 W.	Capt. T. J. Lee, U. S. E., assistant Coast Survey; at Fort McHenry, in $\phi = 39° 15'.7$, $\lambda = 76° 34'.8$; Coast Survey Report for 1854, p. 144.*
4	1856, September 13	2 29.3 W.	Charles A. Schott, assistant Coast Survey; outside Fort McHenry, in $\phi = 39° 15'.8$, $\lambda = 76° 35'.1$; Coast Survey Report of 1858, p. 191.

WILLIAMSBURGH, JAMES CITY COUNTY, VA.

$\phi = 37° 16'.2$ $\lambda = 76° 42'.4$ W. of Gr.

		° ′	
1	1694	5 00 W.	Bishop Madison, president of William and Mary's College, in $\phi = 37° 15'$, $\lambda = 76° 35'$; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838.
2	1780	0 50 W.	
3	1809	0 33 E.	

NEW BERNE, N. C.

$\phi = 35° 06'$ $\lambda = 77° 02'$ W. of Gr.

		° ′	
1	1796	2 40 E.	Jonath. Price; from Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838; position assigned, $\phi = 35° 20'$, $\lambda = 77° 05'$.
2	1806	2 00 E.	
3	1809	1 45 E.	

MOBILE, ALA.

$\phi = 30° 41'.4$ $\lambda = 88° 02'.5$ W. of Gr.

(Episcopal Church.)

		° ′	
1	1809	8 10 E.	J. H. Weakly; in $\phi = 30° 40'$, $\lambda = 88° 11'$ (probably a misprint for 88° 01′); Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838.
2	1814	6 30 E.	Kent; Encyc. Brit., 7th edition, 1842; for Mobile Bay, in $\phi = 30° 13'$, $\lambda = 88° 21'$.
3	1835	7 12 E.	J. H. Weakly; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838.
4	1840	7 05 E.	Chart of Mobile Bay by E. and G. W. Blunt; Coast Survey Report of 1845, p. 42.
5	1843	6 56 E.	Commander L. M. Powell, U. S. N. (in a report); at Mobile Point light, $\phi = 30° 13'.8$, $\lambda = 88° 01'.5$; reduction to Mobile City insensible; Coast Survey Report of 1855, p. 323.
6	1847, May 21-30	7 04.1 E.	R. H. Fauntleroy, assistant Coast Survey; at Fort Morgan, in $\phi = 30° 13'.8$, $\lambda = 88° 01'.4$; Coast Survey Report of 1854, p. *145.
7	1857, February 14-18	6 52.2 E.	Edward Goodfellow, assistant Coast Survey; at Mobile City, near Episcopal Church, in $\phi = 30° 41'.4$, $\lambda = 88° 02'.5$; Coast Survey Report of 1858, p. 192.

Collection of Magnetic Declinations, etc.—Continued.

FLORENCE, ALA.

$\phi = 34° 47'.2$ $\lambda = 87° 41'.7$ W. of Gr.

(Coast Survey station.)

		° ′		
1	1818	6 35	E.	J. H. Weakly; Professor Loomis' collection, in Sill. Jour., vol. xxxiv, 1838; position assigned, $\phi = 34° 50'$, $\lambda = 87° 47'$.
2	1835	6 28	E.	
3	1865, April 17	5 24	E.	A. T. Mosman, assistant Coast Survey; MS. in Coast Survey archives.

SAINT LOUIS, MO.

$\phi = 38° 38'.0$ $\lambda = 90° 12'.2$ W. of Gr.

(Washington University.)

		° ′		
1	1819, June 17	10 47.6	E.*	Maj. S. H. Long; at St. Louis, in $\phi = 38° 36'$, $\lambda = 90° 06'$ [about 5' in error—Sch.]; Account of an Expedition from Pittsburgh to the Rocky Mountains in 1819 and 1820, by Maj. S. H. Long, Philadelphia, 1823.
2	1835	8 49	E.	Colonel Nicolls; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
	1855	8 00	E.	Colton's General Atlas, New York, 1873.
3	1856, October 31	6 23.1	E.	Karl Friesach, Berichte der Kai. Acad. der Wiss., Vienna, vol. xxix, 1858.
4	1872, July and August	6 37.8	E.	Dr. T. C. Hilgard, observer; Bache-Fund Magnetic Survey; MS. communication; two stations, south and west of court-house; first on Compton Hill, in $\phi = 38° 37'.1$, $\lambda = 90° 14'.0$; second near City Hospital, in $\phi = 38° 36'.5$, $\lambda = 90° 12'.7$.

* This value is probably somewhat too great.—Sch.

CAPE MENDOCINO, CAL.

$= 40° 26'.3$ $\lambda = 124° 24'.2$ W. of Gr.

(Cape Mendocino light-house.)

		° ′		
1	1693	2 00	E.	Carreri; C. Hansteen's Magnetismus der Erde, 1819; in $\phi = 40° 29'$, $\lambda = 124° 29'$. [Declination possibly much in error.—Sch.]*
2	1786, September 8	14 24	E.	La Pérouse; C. Hansteen's Magnetismus der Erde, 1819; same position assigned.*
3	1792, April 18	16 00	E.	Capt. G. Vancouver; near the cape, about ten leagues from it; it bore N. 36° W. [This would put him in about $\phi = 39° 58'$, $\lambda = 124° 12'$.—Sch.] Vancouver's Voyage of Discovery, etc., 1790–95, London, 1798, vol. 1, p. 197.
	1792, April 19	15 00	E.	Same authority, vol. 1, p. 198; on board ship, in $\phi = 40° 03'$, $\lambda = 124° 09'$; Cape Mendocino bore N. 2° W. four leagues from shore.
	1792, April 22	16 00	E.	Same authority, vol. 1, p. 200; in $\phi = 40° 32'$, $\lambda = 124° 32'$.

* The latitude given would indicate that this navigator refers to False Cape Mendocino (now called Cape Fortunas, in $\phi = 40° 30'.5$, 124° 22'.8—Sch).

NOOTKA, VANCOUVER ISLAND.

$\phi = 49° 35'.5$ $\lambda = 126° 37'$ W. of Gr.

(Friendly Cove.)

		° ′		
1	1778, April 4	19 45	E.	Cook; in Resolution Cove, $\phi = 49° 35'$, $\lambda = 126° 37$; Hansteen's Magnetismus der Erde, 1819; also Encyc. Metrop., 1848.
2	1791, August 16, 17	22 30	E.	Don A. Malaspina; observed on shore; Berliner Astronomisches Jahrbuch, vol. 53, for 1828.
3	1792, October	18 22	E.	Vancouver; in $\phi = 49° 34'$, $\lambda = 126° 28'$, in Nootka Sound; Hansteen's Magnetismus der Erde, 1819.
4	1863	23 05	E.	Capt. G. H. Richards, R. N.; in Friendly Cove, $\phi = 49° 35\frac{1}{4}'$, $\lambda = 126° 37'.5$; Admiralty Chart of Nootka Sound, No. 1916, 1865; magnetic variation increasing about 2' annually.

Collection of Magnetic Declinations, etc.—Continued.

PETROPAULOVKI, KAMTCHATKA.

$\phi = 53° 01'$ $\lambda = 201° 19'$ W. of Gr.

			°	′		
	1825.5	....	4	13	E.	Gen. Sir E. Sabine's Contributions to Terr. Mag., No. xiii, Phil. Trans. Roy. Soc., 1872. [This is presumed to refer to Captain Beechey's determination below.—Sch] $\phi = 53° 00'$, $\lambda = 201° 20'$ W.
1	1827, July	....	4	13. 3	E.	Beechey's Voyage to the Pacific, 1825 to 1828, London, 1831. [Mean of nine determinations.]
	1827.5	....	3	43	E.	Gen. Sir E. Sabine's Contributions to Terr. Mag., No. xiii, as above. [Beechey's value used in preference.—Sch]
2	1829.5	....	4	04	E.	Reference as above.
3	1849.5	....	2	37	E.	
4	1856, October	....	3	24	E.	Admiralty Chart No. 2460. [Position in Encyc. Brit., 7th edition, $\phi = 53° 01'$, $\lambda = 201° 17'$ W.]

N. B.—This Asiatic station is included in the discussion on account of its proximity to the Western Aleutian or Rat Islands.

The following table contains the empirical expressions for the magnetic declinations, derived from the preceding observations by the process explained above, for various localities, together with their latitudes and longitudes. Total number of stations 43, and of observations about 417.

Locality.	Latitude.		Longitude.		Expression for magnetic declination.
	°	′	°	′	
Halifax, N. S	44	39.6	63	35.3	$D = +15.94° + 4.42° \sin (1.0\ m + 49.2°)$
Quebec, Canada	46	48.4	71	14.5	$D = +12.67 + 3.84 \sin (1.65\ m + 43.6)$
York Factory on Hudson Bay	57	00	92	26	$D = +5.08 + 14.12 \sin (1.6\ m - 79.4)$
Portland, Me	43	38.8	70	16.6	$D = +10.72 + 2.68 \sin (1.33\ m + 24.1)$
Burlington, Vt	44	28.2	73	12.3	$D = +11.16 + 3.76 \sin (1.30\ m - 26.3) + 0.18° \sin (7.2\ m + 138°)$
Rutland, Vt	43	36.5	72	55.5	$D = +9.76 + 3.64 \sin (1.6\ m - 19.6)$
Portsmouth, N. H	43	04.8	70	43.0	$D = +10.29 + 2.56 \sin (1.37\ m + 5.9)$
Newburyport, Mass	42	48.4	70	49.0	$D = +9.63 + 2.63 \sin (1.4\ m + 13.2)$
Salem, Mass	42	31.9	70	52.5	$D = +10.22 + 4.04 \sin (1.55\ m - 6.1)$
Boston, Mass	42	21.5	71	03.8	$D = +9.46 + 2.83 \sin (1.3\ m + 4.6)$
Cambridge, Mass	42	22.9	71	07.7	$D = +9.58 + 2.69 \sin (1.3\ m + 7.0) + 0.18 \sin (3.2\ m + 44)$
Nantucket, Mass	41	17.0	70	06.0	$D = +8.94 + 2.45 \sin (1.35\ m + 13.8)$
Providence, R. I	41	49.5	71	24.1	$D = +9.10 + 2.99 \sin (1.45\ m - 3.4) + 0.19 \sin (7.2\ m + 116)$
Hartford, Conn	41	46.0	72	40.8	$D = +8.06 + 2.90 \sin (1.25\ m - 26.4)$
New Haven, Conn	41	18.5	72	55.7	$D = +7.83 + 3.16 \sin (1.4\ m - 21.6)$
Albany, N. Y	42	39.2	73	45.8	$D = +8.22 + 3.05 \sin (1.44\ m - 9.7)$
Oxford, N. Y	42	26.5	75	40.5	$D = +6.19 + 3.24 \sin (1.35\ m - 18.9)$
Buffalo, N. Y	42	52.8	78	53.5	$D = +3.40 + 3.41 \sin (1.4\ m - 23.3)$
Erie, Pa	42	07.8	80	05.4	$D = +1.27 + 2.00 \sin (1.4\ m - 10.5)$
Cleveland, Ohio	41	30.3	81	42.0	$D = -0.34 + 1.89 \sin (1.4\ m + 6.0)$
Detroit, Mich	42	20.0	83	03.0	$D = -0.96 + 2.22 \sin (1.5\ m - 15.7)$
New York, N. Y	40	42.7	74	00.4	$D = +6.43 + 2.29 \sin (1.6\ m - 5.5) + 0.14 \sin (6.3\ m + 64)$
Hatborough, Pa	40	12	75	07	$D = +5.23 + 3.28 \sin (1.54\ m - 13.2) + 0.22 \sin (4.1\ m + 157)$
Philadelphia, Pa	39	56.9	75	09.0	$D = +5.42 + 3.35 \sin (1.55\ m - 22.9)$
Washington, D. C	38	53.3	77	00.6	$D = +1.79 + 1.90 \sin (1.5\ m + 5.9)$
Cape Henry, Va	36	55.5	76	00.5	$D = +2.95 + 2.95 \sin (1.55\ m - 35.3)$
Charleston, S. C	32	46.6	79	55.8	$D = -2.75 + 2.38 \sin (1.6\ m + 15.2)$
Savannah, Ga	32	04.9	81	05.5	$D = -2.54 + 2.32 \sin (1.5\ m - 28.6)$
Key West, Fla	24	33.5	81	48.5	$D = -4.75 + 2.54 \sin (1.4\ m - 16.4)$
Havana, Cuba	23	08	82	22	$D = -4.82 + 1.44 \sin (1.3\ m - 38.2)$
Kingston, Jamaica	17	55	76	50	$D = -4.69 + 1.95 \sin (1.2\ m + 16.0)$
New Orleans, La	29	57.2	90	03.9	$D = -5.68 + 2.52 \sin (1.4\ m - 63.8)$
Vera Cruz, Mexico	19	12	96	09	$D = -3.77 + 5.89 \sin (1.1\ m - 60.5)$
Mexico, Mexico	19	25.9	99	06	$D = -4.30 + 4.59 \sin (1.1\ m - 76.5)$
Acapulco, Mexico	16	50.5	99	52.3	$D = -3.97 + 4.96 \sin (1.05\ m - 76.7)$
Panama, New Granada	8	55	79	30	$D = -6.28 + 1.57 \sin (1.2\ m - 13.9)$
San Blas, Mexico	21	32.6	105	15.7	$D = -5.60 + 3.37 \sin (1.0\ m - 87.7)$
San Diego, Cal	32	42.1	117	14.3	$D = -12.54 + 1.64 \sin (1.2\ m - 180.0)$
Monterey, Cal	36	36.2	121	53.6	$D = -12.82 + 3.54 \sin (1.0\ m - 142.9)$
San Francisco, Cal	37	47.5	122	27.2	$D = -13.50 + 3.10 \sin (1.0\ m - 132.7)$
Cape Disappointment, W. T	46	16.7	124	02.0	$D = -20.72 + 2.81 \sin (1.2\ m - 188.8)$
Sitka, Alaska	57	02.9	135	19.7	$D = -29.08 - 0.010\ m + 0.00098\ m^2$
Unalaska Island, Alaska	53	52.6	166	31.5	$D = -20.05 + 0.024\ m + 0.00080\ m^2$

In the second table are exhibited for each locality discussed the observed and computed (by preceding formulæ) declinations expressed in degrees and fractions of a degree.

Comparison of Magnetic Declinations observed, and computed by preceding formulæ.

Place.	Year.	Observed.	Computed.
		°	°
Halifax, Nova Scotia.	1756.5	+12.83	+12.85
	1775.5	13.58	14.05
	1798.5	16.50	15.76
	1818.0	17.47	17.25
	1821.7	17.60	17.52
	1852.5	18.17	19.41
	1853.0	18.85	19.44
	1860.5	19.92	19.76
	1866.3	+21.09	+19.97
Quebec, Canada......	1649.5	+16.0	+16.34
	1686.5	15.5	15.44
	1810.5	11.0	11.25
	1814.5	11.83	11.67
	1831.5	13.63	13.54
	1834.5	14.23	13.86
	1842.5	14.20	14.66
	1858.8	15.57	15.93
	1859.5	16.28	15.97
	1860.8	+16.47	+16.04
York Factory........	1725.5	+19.0	+19.04
	1787.5	+ 5.0	+ 4.93
	1819.7	− 6.0	− 6.06
	1843.5	− 9.42	− 9.05
	1857.6	− 7.62	− 7.95
Portland, Me.........	1763.5	+ 7.75	+ 8.05
	1775.5	8.50	8.14
	1845.4	11.47	11.55
	1851.6	11.69	11.91
	1859.5	12.33	12.33
	1863.5	12.47	12.52
	1864.8	12.73	12.58
	1865.5	12.71	12.61
	1866.1	12.72	12.64
	1873.7	+12.89	+12.94
Burlington, Vt.......	1793.5	+ 7.63	+ 7.63
	1818.5	7.50	7.51
	1822.5	7.70	7.69
	1826.5	7.60	7.94
	1830.5	8.17	8.21
	1831.5	8.25	8.29
	1832.5	8.42	8.37
	1834.5	8.83	8.52
	1837.5	8.75	8.75
	1845.5	9.37	9.33
	1855.7	9.95	9.94
	1873.8	+11.32	+11.32
Rutland, Vt..........	1789.3	+ 7.05	+ 6.51
	1810.4	6.07	6.14
	1811.7	6.02	6.16
	1859.6	9.82	9.49
	1873.8	+10.67	+10.91
Portsmouth, N. H....	1771.5	+ 7.77	+ 7.78
	1775.5	7.75	7.74
	1850.7	10.50	10.60
	1859.5	+11.25	+11.12

Place.	Year.	Observed.	Computed.
		°	°
Newburyport, Mass.	1775.5	+ 6.75	+ 7.00
	1781.5	7.30	7.02
	1850.7	10.09	10.28
	1859.5	+10.97	+10.81
Salem, Mass........	1781.6	+ 6.90	+ 6.47
	1805.8	5.95	6.32
	1810.5	6.09	6.49
	1849.6	10.24	9.75
	1855.6	+10.83	+10.40
Boston, Mass.......	1700.5	+10.0	+ 9.95
	1708.5	9.0	9.45
	1741.5	7.5	7.52
	1776.0	7.67	6.62
	1782.5	7.00	6.64
	1793.5	6.50	6.82
	1807.5	6.08	7.28
	1839.5	9.10	9.03
	1846.7	9.52	9.49
	1855.6	10.23	10.05
	1872.7	+11.25	+11.01
Cambridge, Mass ...	1708.5	+ 9.0	+ 9.30
	1742.5	8.0	7.70
	1757.5	7.33	7.28
	1761.5	7.23	7.17
	1763.5	7.00	7.13
	1780.5	7.03	6.90
	1782.5	6.75	6.89
	1783.5	6.87	6.90
	1788.5	6.63	6.93
	1810.5	7.50	7.52
	1835.5	8.85	9.02
	1837.5	9.15	9.15
	1840.4	9.30	9.36
	1842.2	9.57	9.49
	1844.5	9.65	9.65
	1845.4	9.53	9.72
	1850.6	9.50	10.07
	1852.5	10.13	10.20
	1854.5	10.21	10.33
	1855.4	10.91	10.39
	1856.5	10.47	10.46
	1859.2	10.80	10.63
	1867.5	+10.70	+11.09
Nantucket, Mass....	1775.5	+ 6.50	+ 6.50
	1834.5	8.45	8.64
	1838.9	9.04	8.89
	1842.7	9.15	9.11
	1843.7	9.17	9.17
	1846.6	9.23	9.33
	1855.6	9.97	9.83
	1867.4	+10.33	+10.42
Providence, R. I	1717.5	+ 9.60	+ 9.73
	1720.5	9.47	9.49
	1725.5	9.23	9.14
	1730.5	+ 8.90	+ 8.85

Place.	Year.	Observed.	Computed.
		°	°
Providence, R. I.—Continued.	1735.5	+ 8.65	+ 8.59
	1740.5	8.25	8.33
	1745.5	7.98	8.02
	1750.5	7.67	7.66
	1755.5	7.35	7.27
	1760.5	6.95	6.88
	1765.5	6.72	6.53
	1769.5	6.50	6.29
	1775.5	6.33	6.15
	1780.5	6.27	6.12
	1785.5	6.22	6.17
	1790.5	6.17	6.25
	1795.5	6.17	6.32
	1800.5	6.25	6.37
	1805.5	6.32	6.40
	1810.5	6.40	6.45
	1815.5	6.50	6.55
	1819.5	6.62	6.75
	1825.5	6.85	7.06
	1830.5	7.17	7.45
	1835.5	7.57	7.90
	1840.5	8.42	8.36
	1841.5	8.52	8.45
	1842.5	8.65	8.53
	1843.5	8.77	8.60
	1855.6	+ 9.52	+ 9.42
Hartford, Conn.....	1786.5	+ 5.42	+ 5.28
	1810.5	4.77	5.25
	1824.5	5.75	5.60
	1829.0	6.05	5.76
	1859.6	7.29	7.34
	1867.6	+ 7.82	+ 7.84
New Haven, Conn..	1761.5	+ 5.78	+ 6.04
	1775.5	5.42	5.27
	1780.5	5.25	5.07
	1811.5	5.17	4.77
	1819.8	4.42	5.00
	1828.5	5.28	5.35
	1835.3	5.68	5.71
	1836.5	5.92	5.78
	1837.9	5.83	5.87
	1840.5	6.17	6.02
	1845.7	6.29	6.37
	1848.6	6.58	6.57
	1855.6	7.05	7.08
	1872.5	+ 8.46	+ 8.37
Albany, N. Y	1817.8	+ 5.73	+ 5.71
	1818.6	5.75	5.78
	1825.3	6.00	6.07
	1828.6	6.27	6.26
	1830.5	6.30	6.37
	1831.6	6.54	6.44
	1834.8	6.67	6.64
	1836.8	6.78	6.77
	1847.9	7.58	7.57
	1855.7	+ 7.91	+ 8.16

Comparison of Magnetic Declinations, etc.—Continued.

Place.	Year.	Observed.	Computed.
		°	°
Albany, N.Y.—Cont'd	1856. 7	+ 8. 58	+ 8. 23
	1858. 4	+ 8. 28	+ 8. 37
Oxford, N. Y.........	1794. 0	+ 3. 00	+ 2. 96
	1817. 5	3. 00	3. 31
	1828. 5	4. 50	3. 79
	1834. 8	3. 87	4. 13
	1836. 8	4 15	4. 26
	1837. 5	4. 50	4. 30
	1838. 5	4. 45	4. 36
	1849. 9	5. 18	5. 14
	1857. 3	5. 73	5. 68
	1858. 1	5. 78	5. 74
	1859. 0	5. 83	5. 81
	1873. 9	6. 87	6. 94
	1874. 4	+ 6. 93	+ 6. 97
Buffalo, N. Y.........	1797. 5	0. 00	+ 0. 01
	1837. 5	+ 1. 42	1. 17
	1839. 5	1. 25	1. 30
	1845. 5	1. 42	1. 71
	1859. 5	2. 94	2. 81
	1872. 5	3. 87	3. 89
	1873. 5	+ 3. 97	+ 3. 97
Erie, Pa	1795. 5	− 0. 72	− 0. 72
	1841. 6	+ 0. 50	+ 0. 51
	1862. 6	1. 55	1. 52
	1873. 4	+ 2. 01	+ 2. 03
Cleveland, Ohio	1796. 7	− 2. 00	− 2. 10
	1830. 5	1. 33	1. 03
	1831. 6	1. 25	0. 98
	1834. 1	0. 83	0. 87
	1838. 1	0. 58	0. 69
	1841. 3	0. 09	0. 54
	1845. 5	− 0. 65	− 0. 35
	1859. 5	+ 0. 77	+ 0. 29
	1871. 8	0. 54	0. 79
	1872. 5	0. 75	0. 81
	1873. 5	+ 0. 85	+ 0. 85
Detroit, Mich	1810 5	− 2. 80	− 3 10
	1822. 5	3. 22	2. 82
	1828. 5	2. 83	2. 61
	1835. 5	2. 17	2. 31
	1840. 5	1. 97	2. 07
	1859. 5	0. 70	1. 01
	1865. 5	0. 67	0. 66
	1872. 4	0. 42	0. 28
	1873. 4	− 0. 29	− 0. 22
New York, N. Y	1686. 5	+ 8. 75	+ 8. 78
	1691. 5	8. 75	8. 68
	1723. 5	7. 33	7. 53
	1750. 5	6. 37	5. 85
	1755. 5	5. 00	5. 46
	1789. 5	4. 33	4. 30
	1824. 5	4. 67	4. 64
	1834. 5	4. 83	5. 17
	1837. 5	5. 67	5. 37
	1840. 6	5. 45	5. 61
	1841. 5	6. 10	5. 68
	1844. 6	+ 6. 22	+ 5. 92
New York, N. Y.—Continued.	1845. 7	+ 6. 42	+ 6. 01
	1846. 3	5. 56	6. 05
	1847. 8	5. 68	6. 16
	1855. 6	6. 72	6. 73
	1860. 7	6. 73	7. 03
	1873. 8	+ 7. 62	+ 7. 63
Hatborough, Pa.....	1680. 5	+ 8. 47	+ 8. 49
	1690. 5	8. 25	8. 30
	1700. 5	7. 92	7. 94
	1710. 5	7. 47	7. 49
	1720. 5	7. 00	6. 95
	1730. 5	6. 42	6. 30
	1740. 5	5. 58	5. 56
	1750. 5	4. 92	4. 67
	1760. 5	4. 00	3. 75
	1770. 5	2. 92	2. 89
	1780. 5	2. 08	2. 21
	1790. 5	1. 83	1. 84
	1800. 5	1. 92	1. 79
	1810. 5	2. 00	2. 07
	1820. 5	2. 45	2. 56
	1830. 5	3. 00	3. 20
	1840. 5	3. 83	3. 89
	1850. 5	+ 4. 42	+ 4. 60
Philadelphia, Pa ...	1701. 5	+ 8. 5	+ 8. 63
	1710. 5	8. 5	8. 30
	1750. 5	5. 75	5. 25
	1793. 5	1. 5	2. 27
	1802. 5	1. 5	2. 08
	1804. 5	2. 08	2. 07
	1813. 5	2. 43	2. 12
	1837. 5	3. 87	3. 16
	1840. 5	3. 62	3. 37
	1841. 7	3. 90	3. 46
	1846. 4	3. 85	3. 82
	1855. 7	4. 53	4. 60
	1862. 6	5. 00	5. 22
	1872. 8	+ 5. 46	+ 6. 14
Washington, D. C...	1792. 5	− 0. 24	− 0. 08
	1809. 9	+ 0. 87	+ 0. 25
	1841. 0	1. 34	1. 54
	1842. 0	1. 40	1. 59
	1855. 5	2. 40	2. 25
	1856. 6	2. 36	2. 30
	1857. 2	2. 41	2. 34
	1860. 7	2. 44	2. 50
	1862. 7	2. 66	2. 59
	1863. 6	2. 70	2. 63
	1866. 8	2. 74	2. 77
	1867. 5	2. 80	2. 80
	1868. 5	2. 85	2. 84
	1869. 3	2. 88	2. 87
	1870. 5	2. 89	2. 92
	1871. 5	2. 95	2. 96
	1872. 5	3. 00	3. 00
	1873. 5	3. 00	3. 04
	1874. 5	+ 3. 10	+ 3. 08
Cape Henry, Va....	1732. 5	+ 4. 68	+ 4. 74
Cape Henry, Va.—Continued.	1809. 5	[0. 00]	+ 0. 03
	1832. 5	+ 0. 75	0. 34
	1856. 7	+ 1. 47	1: 71
	1865. 8	[+2. 54]	+ 2. 40
Charleston, S. C.....	1742. 5	[−5. 38]	− 3. 69
	1775. 5	− 3. 80	5. 06
	1784. 1	5. 25	5. 13
	1785. 8	5. 75	5. 13
	1825. 0	3. 75	3. 75
	1837. 5	2. 90	2. 95
	1841. 4	2. 40	2. 69
	1847. 8	2. 25	2. 27
	1849. 3	2. 28	2. 17
	1874. 4	− 0. 97	− 0. 82
Savannah, Ga.......	1817. 5	− 4. 00	− 4. 68
	1839. 0	4. 30	4. 18
	1852. 3	3. 67	3. 52
	1857. 3	3. 46	3. 24
	1874. 2	− 1. 98	− 2. 23
Key West, Fla......	1829. 1	− 6. 42	− 6. 57
	1843. 5	6. 03	5. 84
	1849. 6	5. 48	5. 49
	1860. 7	4. 78	4. 81
	1861. 2	4. 75	4. 78
	1862. 7	4. 68	4. 69
	1863. 5	4. 60	4. 64
	1864. 5	4. 56	4. 58
	1865. 5	4. 52	4. 52
	1866. 2	− 4. 49	− 4. 47
Havana, Cuba	1726. 5	− 4. 4	− 4. 37
	1732. 3	4. 5	4. 54
	1815. 5	7. 0	6. 25
	1816. 6	5. 5	6. 24
	1857. 1	5. 25	5. 52
	1858. 5	− 5. 75	− 5. 48
Kingston, Jamaica..	1732. 2	− 6. 0	− 6. 28
	1791. 8	6. 78	6. 26
	1806. 0	6. 5	5. 86
	1820. 5	4. 8	5. 34
	1822. 5	4. 9	5. 26
	1832. 5	5. 2	4. 86
	1833. 5	4. 7	4. 82
	1837. 8	4. 3	4. 56
	1847. 3	3. 67	4. 24
	1857. 2	3. 67	3. 88
	1866. 5	− 4. 95	− 3. 55
New Orleans, La....	1720. 5	− 2. 0	− 3. 39
	1768. 5	7. 83	5. 77
	1796. 5	5. 10	7. 34
	1806. 5	8. 05	7. 75
	1840. 5	8. 33	8. 14
	1857. 0	8. 00	7. 72
	1858. 3	7. 86	7. 67
	1870. 5	7. 10	7. 13
	1872. 1	− 6. 99	− 7. 05
Vera Cruz, Mexico..	1727. 0	− 2. 25	− 2. 17
	1769. 4	− 6. 57	− 6. 79

Comparison of Magnetic Declinations, etc.—Continued.

Place.	Year.	Observed.	Computed.	Place.	Year.	Observed.	Computed.	Place.	Year.	Observed.	Computed.
		°	°			°	°			°	°
Vera Cruz, Mexico—	1776.5	— 7.5	— 7.46	San Blas, Mexico....	1791.3	— 7.47	— 7.46	San Francisco, Cal.—	1866.5	—16.42	— 16.28
Continued.	1815.5	10.6	9.60		1822.0	8.67	8.64	Continued.	1872.8	16.43	16.41
	1819.3	9.3	9.65		1837.5	8.57	8.92		1873.6	16.42	16.43
	1856.6	8.3	8.49		1839.5	9.00	8.94		1874.0	—16.47	— 16.44
	1861.0	— 8.3	— 8.18		1841.5	— 9.20	— 8.95	Cape Disappointment, W. T.	1792.3	—18.00	— 17.98
Mexico, Mexico	1769.8	— 5.45	— 5.51	San Diego, Cal......	1792.5	—11.00	—11.01		1839.5	19.18	19.70
	1804.0	8.13	7.94		1839.5	12.34	12.18		1842.5	20.00	19.86
	1850.5	8.59	8.75		1851.3	12.48	12.58		1851.5	20.54	20.38
	1856.9	8.77	8.58		1853.8	12.53	12.67		1873.8	—21.61	— 21.67
	1858.5	8.37	8.53		1866.4	13.16	13.09	Sitka, Alaska	1804.5	—26.75	— 26.58
	1860.5	8.50	8.46		1872.9	—13.32	—13.29		1824.5	27.50	28.18
	1862.5	8.34	8.38	Monterey, Cal.......	1791.7	—10.93	—11.48		1827.5	28.83	28.36
	1867.0	8.15	8.18		1795.5	12.37	11.76		1829.5	28.32	28.46
	1868.5	— 8.17	— 8.11		1837.5	14.50	14.29		1830.0	28.27	28.48
Acapulco, Mexico....	1744.5	— 3.0	— 3.32		1839.5	14.22	14.40		1838.5	28.62	28.83
	1791.3	7.73	7.26		1841.5	15.00	14.51		1839.5	29.53	28.86
	1822.5	8.67	8.74		1843.5	14.00	14.62		1842.5	28.88	28.95
	1828.5	9.12	8.85		1851.1	14.97	15.01		1851.0	29.23	29.09
	1838.0	8.29	8.91		1873.7	—15.92	—15.91		1867.6	—28.82	— 28.95
	1866.5	— 8.37	— 8.23	San Francisco, Cal ..	1792.9	—12.80	—12.97	Unalaska Island....	1792.5	—19.0	— 18.79
Panama, New Granada.	1775.8	— 7.8	— 7.80		1827.5	15.45	14.80		1806.5	19.4	19.58
	1790.8	7.8	7.83		1829.5	15.10	14.90		1829.0	19.9	20.20
	1802.5	8.0	7.76		1837.5	15.17	15.27		1848.5	19.51	20.08
	1822.5	7.0	7.42		1839.5	15.33	15.35		1849.5	20.00	20.06
	1837.5	7.03	7.03		1841.9	15.50	15.46		1867.7	19.79	19.38
	1849.5	7.08	6.67		1850.0	15.68	15.78		1870.5	19.75	19.22
	1866.4	— 5.93	— 6.12		1852.3	—15.48	—15.86		1873.4	—19.00	— 19.05

The third table shows the number of observations at each place; the apparent probable error of one observation (including errors arising from want of identity of stations and from instrumental defects), expressed in minutes of arc; the computed epoch of greatest easterly deflection in the secular motion, together with the amount and direction of the declination at that epoch; and the computed annual changes at the epochs 1870 and 1880, expressed in minutes.

Locality.	Number of observations.	Apparent probable error of an observation.	Epoch of *easterly* secular digression (needle stationary).	Amount when at easterly digression.	Annual change. In 1870.	Annual change. In 1880.
		′		°	′	′
Halifax, Nova Scotia	9	±33	1711	+11.5	+1.6	+0.9
Quebec, Canada	10	15	1769	+ 8.8	+1.7	....
York Factory on Hudson Bay	5	14	....	....	....	....
Portland, Me	10	9	1764	+ 8.0	+2.4	+1.6
Burlington, Vt	12	6	1810	+ 7.4	+5.7	+6.0
Rutland, Vt	5	15	1807	+ 6.1	+5.9	+5.4
Portsmouth, N. H	4	5	1780	+ 7.7	+3.1	+2.5
Newburyport, Mass	4	13	1776	+ 7.0	+2.9	+2.2
Salem, Mass	5	26	1796	+ 6.2	+5.9(?)	+5.0(?)
Boston, Mass	11	25	1777	+ 6.6	+3.3	+2.8
Cambridge, Mass	23	11	1783	+ 6.9	+2.9	+2.1
Nantucket, Mass	8	6	1773	+ 6.5	+2.6	+2.3
Providence, R. I	30(?)	7	1780	+ 6.1	+3.8	....
Hartford, Conn	6	14	1799	+ 5.2	+3.4	+3.0
New Haven, Conn	14	9	1801	+ 4.7	+4.6	+4.3
Albany, N. Y	12	6	1794	+ 5.2	+4.3	+3.8
Oxford, N. Y	13	9	1797	+ 3.0	+4.5	+4.3
Buffalo, N. Y	7	8	1802	0.0	+4.9	+4.7
Erie, Pa	4	......	1793	− 0.7	+2.8	+2.5
Cleveland, Ohio	11	12	1781	− 2.2	+2.3	+1.9
Detroit, Mich	9	11	1801	− 3.2	+3.4	+3.0
New York, N. Y	18	15	1797	+ 4.0	+2.4	+2.5
Hatborough, Pa	18(?)	6	1797	+ 1.8	+4.6	+4.5(?)
Philadelphia, Pa	14	20	1807	+ 2.1	+4.7	+3.7
Washington, D. C	19	6	1786	− 0.1	+2.4	+1.9
Cape Henry, Va	5	14	1815	0.0	+4.8(?)	+4.7(?)
Charleston, S. C	9	19	1784	− 5.1	+2.7	+1.8
Savannah, Ga	5	15	1809	− 4.9	+3.6	+3.5
Key West, Fla	10	4	1797	− 7.3	+3.6	+3.4
Havana, Cuba	6	26	1810	− 6.3	+1.9	....
Kingston, Jamaica	11	25	....	− 6.6	+1.9	....
New Orleans, La	9	30	1831	− 8.2	+3.0	+3.4
Vera Cruz, Mexico	7	17	1823	− 9.7	+5.3	....
Mexico, Mexico	9	5	1838	− 8.9	+3.1	+3.8
Acapulco, Mexico	6	21	1837	− 8.9	+3.1	+3.8
Panama, New Granada	7	13	1787	− 7.9	+1.9	+1.8
San Blas, Mexico	5	10	1848	− 9.0	+1.3	....
San Diego, Cal	6	6	(1925)	−14.2	−1.9	−1.7
Monterey, Cal	8	21	(1903)	−16.4	−2.0	−1.5
San Francisco, Cal	12	9	(1893)	−16.6	−1.3	−0.7
Cape Disappointment, W. T	5	12	(1932)	−23.5(?)	−3.4	−3.1
Sitka, Alaska	10	18	1855	−29.1	+1.8	+2.9
Unalaska Island, Alaska	8	±17	1835	−20.2	+3.4	+4.4

The probable errors given above will serve to convey some rude idea of the relative value of *each series* of observations. The imperfections in the instrumental means of the older observations in many cases react unfavorably on the modern observations made with more precise instruments; the observations, for instance, taken by Hudson in 1609, in the vicinity of New York Bay, are

fairly chargeable with a probable error of $\pm 3^\circ$ (a single result); those taken by Vancouver on our western coast, between 1792 and 1794, are subject to a probable uncertainty of $\pm 1^\circ$ (each). Increased precision was obtained with the improvement of the azimuth compass and the allowance for disturbing effect of the ship's iron, and, for shore stations, with the introduction of the theodolite for determining the astronomical meridian. With a portable magnetometer (collimator-magnet), the *instrumental* means need not leave a greater uncertainty than about one minute; but the *actual probable error* of any determination is limited by the accidental variations in the mean direction of the magnetic force from day to day, making it desirable to continue the observations for three or more days, and correcting them for daily variation. The amount of the probable error is also dependent on the magnitude of the horizontal force.

A cursory examination of the column containing the epochs of greatest *easterly* excursion, the *deflecting* force producing the secular change attaining then an easterly maximum, shows that the needle became stationary in direction, and then reversed its secular motion, in the New England States toward the end of the past century, in the Atlantic coast States to the west and south early in the present, and in Mexico about the close of the first third of the present century. In California, Oregon, and Washington Territory, it has not yet reached this condition. We thus have the following epochs for comparison: Halifax, about 1711; Portland, Portsmouth, Newburyport, Salem, Boston, Cambridge, Nantucket, and Providence, about 1779; Hartford, New Haven, New York, Hatborough, Philadelphia, Washington, and Cape Henry, about 1800; Charleston, Savannah, Key West, and Havana, about 1800; New Orleans, about 1831; Vera Cruz, Mexico, Acapulco, and San Blas, about 1837; San Diego, Monterey, and San Francisco, expected about 1907 (yet very uncertain).

We are thus directed to the extreme northeastern States for probable indications of what may be expected to follow on the seaboard in more southern and western States. Respecting the secular movement of the needle, apparently a little more than a century passed before the influence which produced the turning of the north end of the needle westward in Maine (increasing there the western declination) was felt in Lower California (diminishing there the eastern declination). In California, Oregon, and Washington Territory, the eastern declination is at present still *increasing*, but with a losing rate. By the time the western elongation of the secular change is reached in Maine, we may expect to see the needle in the *opposite* phase, or at its eastern elongation in California. We cannot as yet follow this influence directly over the interior of the United States for want of early observations; the westernmost interior stations for which an epoch could be made out were Buffalo, Erie, Cleveland, and Detroit; these give the average turning epoch 1794. It may be quite practicable hereafter to trace out curves uniting all stations where the needle was stationary at a given epoch, and again at other epochs for regular intervals of time, say of ten or twenty-five years.

Returning to the first table, the constant in each formula would represent the normal direction of the needle about which the motion constituting the secular change would be performed in an average cycle of about two hundred and seventy years, and with extreme deflections on either side of it equal to the coefficient of the periodic term, all under the *supposition* that the law of the secular movement was truly expressed. It is no doubt much more complex, and besides may fail at any time; yet, as far as our present experience reaches, and within the interval when the first reliable observations were made to the present time, it is found trustworthy.

Table of decennial values of the Magnetic Declination computed from preceding equations.

These tables have been constructed to facilitate the reduction of observed declinations from one epoch to another; they will be found specially useful when old lines, run by compass, have to be retraced, and for the construction of isogonic charts for a given epoch.

Blanks occurring in the table indicate no or doubtful values for the corresponding times. Values given to the nearest tenth of a degree are less reliable than those given to hundredths. A + sign indicates west, a — sign east declination.

Year (Jan. 1).	Halifax, Nova Scotia.	Quebec, Canada.	York Factory.	Portland, Me.	Burlington, Vt.	Rutland, Vt.	Portsmouth, N. H.	Newburyport, Mass.	Salem, Mass.	Boston, Mass.	Cambridge, Mass.	Nantucket, Mass.	Providence, R. I.	Hartford, Conn.	New Haven, Conn.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1640	......	+15.9	......	......	......	......	......	......	......	......	......	......	......	......	......
50	......	16.4	......	......	......	......	......	......	......	......	......	......	......	......	......
60	......	16.5	......	......	......	......	......	......	......	......	......	......	......	......	......
70	......	16.4	......	......	......	......	......	......	......	......	......	......	......	......	......
80	......	15.9	......	......	......	......	......	......	......	......	......	......	......	......	......
90	......	+15.2	......	......	......	......	......	......	......	......	......	......	......	......	......
1700	......	......	......	......	......	......	......	......	......	+10.0	+9.8	......	......	......	......
10	......	......	......	......	......	......	......	......	......	9.3	9.2	......	+10.4	......	......
20	......	......	+18.6	......	......	......	......	......	......	8.7	8.7	......	9.5	......	......
30	......	......	19.2	......	......	......	......	......	......	8.1	8.3	......	8.9	......	......
40	......	......	18.8	......	......	......	......	......	......	7.6	7.9	......	8.4	......	......
50	+12.5	......	17.2	......	......	......	......	......	......	7.2	7.5	......	7.7	......	......
60	13.0	......	14.8	+8.1	......	......	......	......	......	6.8	7.2	......	6.9	......	+6.1
70	13.7	......	11.6	8.1	......	......	+7.8	+7.0	......	6.7	7.0	+6.5	6.3	......	5.5
80	14.4	......	7.9	8.2	......	+7.0	7.7	7.0	+6.4	6.6	6.9	6.5	6.12	+5.4	5.1
90	15.1	......	4.0	8.5	+7.7	6.5	7.8	7.2	6.2	6.7	6.9	6.7	6.24	5.2	4.8
1800	15.9	......	+0.1	8.9	7.52	6.2	8.0	7.4	6.2	7.0	7.1	7.0	6.37	5.16	4.7
10	16.7	+11.2	—3.3	9.4	7.39	6.14	8.4	7.8	6.5	7.4	7.5	7.4	6.45	5.24	4.8
20	17.4	12.3	—6.1	10.0	7.58	6.39	8.8	8.4	7.0	7.9	8.0	7.84	6.73	5.46	5.0
30	18.1	13.4	—8.1	10.6	8.17	6.90	9.35	9.0	7.8	8.43	8.64	8.38	7.43	5.80	5.43
40	18.7	14.4	—9.0	11.23	8.94	7.64	9.94	9.6	8.7	9.05	9.33	8.95	8.31	6.24	5.99
50	19.3	15.3	—8.8	11.82	9.62	8.53	10.55	10.23	9.8	9.69	10.03	9.53	9.09	6.77	6.67
60	19.8	16.0	—7.5	12.35	10.21	9.53	11.15	10.83	10.9	10.32	10.67	10.06	9.65	7.36	7.41
70	20.1	+16.4	—5.3	12.80	10.97	10.54	11.7	11.4	11.9	10.90	11.21	10.54	10.21	7.99	8.18
1880	+20.3	......	......	+13.13	+11.97	+11.49	+12.2	+11.8	+12.8	+11.41	+11.63	+10.93	+10.94	+8.62	+8.9

Table of decennial values of the Magnetic Declination, etc.—Continued.

Year (Jan. 1).	Albany, N. Y.	Oxford, N. Y.	Buffalo, N. Y.	Erie, Pa.	Cleveland, Ohio.	Detroit, Mich.	New York, N. Y.	Hatborough, Pa.	Philadelphia, Pa.	Washington, D. C.	Cape Henry, Va.	Charleston, S. C.	Savannah, Ga.	Key West, Fla.	Havana, Cuba.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1640	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
50	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
60	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
70	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
80	......	......	......	......	......	......	+8.8	+8.5	......	......	......	......	......	......	......
90	......	......	......	......	......	......	8.8	8.3	......	......	......	......	......	......	......
1700	......	......	......	......	......	......	8.5	7.9	+8.7	......	......	......	......	......	......
10	......	......	......	......	......	......	8.0	7.5	8.3	......	......	......	......	......	......
20	......	......	......	......	......	......	7.6	7.0	7.8	......	......	......	......	......	−4.2
30	......	......	......	......	......	......	7.2	6.3	7.0	......	+4.9	......	......	......	−4.5
40	......	......	......	......	......	......	6.6	5.6	6.2	......	+4.2	−3.1	......	......	−4.8
50	......	......	......	......	......	......	5.9	4.7	5.3	......	......	−4.1	......	......	......
60	......	......	......	......	......	......	5.2	3.8	4.4	......	......	−4.6	......	......	......
70	......	......	......	......	......	......	4.6	2.9	3.6	......	......	−4.9	......	......	......
80	......	......	......	......	......	......	4.4	2.2	2.9	......	......	−5.1	......	......	......
90	......	+3.01	+0.14	−0.7	−2.2	......	4.29	1.8	2.4	−0.1	......	−5.1	......	......	......
1800	......	2.96	−0.01	−0.7	−2.0	−3.18	4.28	1.8	2.1	0.0	+0.2	−4.9	......	......	−6.2
10	+5.4	3.10	+0.05	−0.6	−1.8	−3.11	4.30	2.03	2.1	+0.3	0.0	−4.5	−4.9	......	−6.26
20	5.79	3.40	0.30	−0.3	−1.5	−2.90	4.47	2.53	2.28	0.6	0.0	−4.04	−4.8	−6.9	−6.22
30	6.32	3.87	0.74	+0.03	−1.05	−2.55	4.91	3.17	2.71	1.0	+0.25	−3.44	−4.5	−6.52	−6.12
40	6.97	4.46	1.33	0.44	−0.60	−2.09	5.59	3.86	3.33	1.49	0.66	−2.78	−4.14	−6.03	−5.94
50	7.70	5.14	2.05	0.91	−0.14	−1.56	6.34	4.57	4.11	1.99	1.24	−2.12	−3.65	−5.47	−5.71
60	8.47	5.89	2.85	1.39	+0.31	−0.99	6.96	5.29	4.99	2.47	1.95	−1.52	−3.08	−4.86	−5.44
70	9.2	6.65	3.68	1.87	0.72	−0.41	7.43	6.0	5.89	2.90	2.73	−1.00	−2.48	−4.24	−5.1
1880	+9.9	+7.38	+4.49	+2.31	+1.07	+0.13	+7.84	+6.8	+6.76	+3.26	+3.5	−0.62	−1.89	−3.65	......

Year (Jan. 1).	Kingston, Jamaica.	New Orleans, La.	Vera Cruz, Mexico.	Mexico, Mexico.	Acapulco, Mexico.	Panama, New Granada.	San Blas, Mexico.	San Diego, Cal.	Monterey, Cal.	San Francisco, Cal.	Cape Disappointment, W. T.	Sitka, Alaska.	Unalaska Island.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1640	......	......	......	......	......	......	......	......	......	......	......	......	......
50	......	......	......	......	......	......	......	......	......	......	......	......	......
60	......	......	......	......	......	......	......	......	......	......	......	......	......
70	......	......	......	......	......	......	......	......	......	......	......	......	......
80	......	......	......	......	......	......	......	......	......	......	......	......	......
90	......	......	......	......	......	......	......	......	......	......	......	......	......
1700	......	......	......	......	......	......	......	......	......	......	......	......	......
10	......	......	......	......	......	......	......	......	......	......	......	......	......
20	......	−3.4	......	......	......	......	......	......	......	......	......	......	......
30	−6.2	−3.7	−2.5	......	......	......	......	......	......	......	......	......	......
40	−6.4	−4.1	−3.6	......	−2.9	......	......	......	......	......	......	......	......
50	......	−4.7	−4.7	......	−3.8	......	......	......	......	......	......	......	......
60	......	−5.3	−5.8	−4.7	−4.7	......	......	......	......	......	......	......	......
70	......	−5.9	−6.8	−5.5	−5.6	−7.7	......	......	......	......	......	......	......
80	......	−6.5	−7.7	−6.4	−6.4	−7.8	......	......	......	......	......	......	......
90	−6.3	−7.0	−8.5	−7.1	−7.2	−7.8	−7.4	−11.0	−11.4	−12.8	−18.0	......	−18.6
1800	−6.0	−7.5	−9.1	−7.7	−7.8	−7.8	−7.9	−11.1	−12.0	−13.4	−18.1	−26.12	−19.3
10	−5.7	−7.9	−9.5	−8.3	−8.3	−7.7	−8.3	−11.3	−12.6	−13.9	−18.4	−27.11	−19.7
20	−5.4	−8.1	−9.6	−8.6	−8.68	−7.5	−8.6	−11.6	−13.3	−14.42	−18.7	−27.89	−20.1
30	−5.0	−8.2	−9.6	−8.8	−8.88	−7.2	−8.8	−11.9	−13.9	−14.92	−19.2	−28.48	−20.2
40	−4.6	−8.14	−9.4	−8.9	−8.91	−6.96	−8.94	−12.20	−14.44	−15.38	−19.72	−28.88	−20.2
50	−4.2	−7.94	−8.90	−8.76	−8.79	−6.66	−8.97	−12.54	−14.95	−15.78	−20.29	−29.08	−20.1
60	−3.8	−7.61	−8.25	−8.48	−8.50	−6.33	−8.89	−12.88	−15.42	−16.11	−20.88	−29.08	−19.7
70	−3.4	−7.15	−7.4	−8.04	−8.06	−6.0	−8.7	−13.20	−15.79	−16.36	−21.46	−28.88	−19.3
1880	......	−6.62	......	−7.46	−7.5	......	......	−13.50	−16.08	−16.52	−22.00	−28.5	−18.6

Neither the secular change of the magnetic dip,* nor that of the horizontal intensity,† can as yet be treated by the use of a harmonic function. Reliable observations for dip hardly date back to the year 1790 on our western coast, while on the eastern coast there are but very few observations earlier than 1833. Respecting the records of horizontal intensity, there are but a few in the United States prior to 1830, and all the earlier observations are expressed in relative measure.‡

* See preliminary investigation, in Coast Survey Report for 1856, Appendices Nos. 32 and 33.

† See preliminary investigation, in Coast Survey Report for 1861, Appendix No. 22.

‡ In 1833, Gauss showed how the magnetic force could be expressed in absolute measure. In 1836, Professor Weber applied the principle to the small portable instruments; in 1838, he used the collimator as proposed by Sir G. B. Airy. For reference, the English reader may consult vol. II of R. Taylor's Scientific Memoirs, London, 1841.

APPENDIX No. 9.

REPORT ON RESULTS OF MAGNETIC OBSERVATIONS, BOTH ABSOLUTE AND DIFFERENTIAL, AT KEY WEST, 1860 TO 1866.

Results of observations of terrestrial magnetism at Key West, Fla., made between 1860 and 1866, under the direction of Prof. W. P. Trowbridge and Mr. S. Walker; discussed and reported by Charles A. Schott, Assistant United States Coast Survey.

DECEMBER 20, 1874.

The series of magnetic observations, both with portable instruments for absolute determinations and with fixed or self-registering instruments for differential determinations, was commenced in February, 1860, and continued to April, 1866, inclusive. The observations at Key West are therefore contemporaneous with the magnetic observations taken at Eastport, Me., up to the close of the latter series in July, 1864.* The Key West series embraces half of an eleven-year cycle.

The Key West Magnetic Observatory is in latitude 24° 33.′1, and in longitude 81° 48.′5 W. of Greenwich. The island is about eighty-nine nautical miles N. 20° E. (true) from Havana, Cuba.

The Coast Survey Magnetic Observatory was established by Prof. W. P. Trowbridge, assistant Coast Survey, in January, 1860, and left in charge of Mr. Samuel Walker and Mr. G. D. Allen. In 1861, it was successively in charge of Messrs. Allen, Walker, and J. G. Oltmanns. In 1862, it was in charge of Messrs. Oltmanns, F. F. Nes, and Walker, and remained under the latter's direction to the close of the work. A full description of the observatory and of the self-registering instruments (including their adjustment) is given by Professor Trowbridge in Coast Survey Report of 1860, Appendix No. 26, pp. 326–349, to which the reader may be referred for matters of detail. The Brooke's magnetographs† were first mounted in the Smithsonian grounds at Washington. (For a description of this observatory and instruments by Assistant J. E. Hilgard, see Smithsonian Report for 1859, p. 385.) From here the instruments were transferred to Key West, and returned to Washington in 1865. After undergoing considerable repairs in September, 1873, they were loaned to the Union University at Schenectady, N. Y.

They consist of a unifilar declinometer, a bifilar magnetometer, and a balance magnetometer, with the necessary revolving barrels, clocks, and photographic outfit. The photographic traces for changes in declination and horizontal and vertical forces were read off and the hourly values tabulated The instruments for absolute measures were magnetometer C. S. No. 6, used between December, 1860, and May, 1861, and magnetometer C. S. No. 2, used before and after that time, for declination and horizontal force; dip-circle C. S. No. 9, used between February and June, 1860, and dip-circle. C. S. No. 8, used between July, 1860, and May, 1861. After this date, No. 9 was again employed for dip. With some exceptions, in the first three years the declination, dip, and horizontal intensity, in absolute measure, were determined on four days about the middle of each month.

The results will be given in the condensed form of tables, accompanied by such explanations, illustrations, and comparisons as the subject demands. For comparison with the Key West results, similar ones obtained at Washington, Philadelphia, Toronto, Eastport, or other stations, will be given.

The results from the absolute measures will be given first, followed by those from the differential measures. The computation of the former was made by Mr. J. Main and Mr. E. H. Courtenay; for those of the latter, I had some assistance from Mr. F. Hudson.

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* See Coast Survey Report for 1865, pp. 166–174, Appendix No. 18.

† Description of an apparatus for the automatic registration of magnetometers and meteorological instruments by photography, by Charles Brooke, M. B., Trans. Roy. Soc., 1847. See also Silliman's Journal of Sc. and Arts, vol. ix, No. 27, May, 1850, Art. xxxii, On the application of photography to the self-registration of magnetical and meteorological instruments, by Capt. J. H. Lefroy, R. A., director of the observatory at Toronto.

Abstract of monthly results for magnetic declination at Key West, 1860 *to* 1866.

The first column gives the result as observed; the second, *as corrected* for daily variation from the table derived from the differential observations; the last column contains the number of days of observation.

	Observed.	Corrected.	Days.
1860.	° ′	° ′	
February 16, 17........	4 57.5 E.	4 57.0 E.	2
March 17..............	42.9	44.2	1
June 1, 2, 4	45.7	45.9	3
December 17 to 31.....	45.5	45.4	14
1861.			
February 27, 28........	4 44.7 E.	4 44.7 E.	2
March 1 to 9	45.5	44.5	7
April 5, 6..............	44.1	44.4	2
1862.			
May 30, 31.............	4 39.7 E.	4 40.6 E.	2
June 1 to 24	40.5	40.3	10
July 12 to 19...........	41.6	40.1	4
August 11 to 26	43.1	40.4	6
September 10 to 19	40.5	40.7	4
October 11 to 19.......	40.1	39.6	5
November 10 to 19	39.0	39.1	4
December 10 to 19.....	38.6	38.7	4
1863.			
January 10 to 20.......	4 38.0 E.	4 38.3 E.	4
February 10 to 19	37.3	37.5	5
March 10 to 19	37.2	37.8	5
April 10 to 20	36.5	37.8	5
May 11 to 20...........	35.8	37.4	4
June 10 to 20..........	37.4	37.5	4
July 10 to 21	35.9	37.3	4
August 10 to 20	35.0	36.5	4
September 10 to 21	35.3	36.8	4
October 10 to 20	34.6	35.3	4
November 10 to 20.....	35.1	35.2	4
December 11 to 22.....	34.7	34.7	6
1864.	° ′	° ′	
January 11 to 21........	4 34.0 E.	4 34.1 E.	5
February 10 to 21.......	34.9	34.8	4
March 10 to 23..........	34.2	34.6	4
April 12 to 24...........	34.4	34.7	5
May 10 to 20............	33.7	34.3	4
June 10 to 18	33.8	34.7	4
July 11 to 19	33.7	33.7	4
August 10 to 19........	34.8	35.1	4
September 10 to 20	34.1	34.6	4
October 10 to 19........	32.2	32.5	4
November 10 to 19......	31.8	32.0	5
December 10 to 20	32.2	32.2	4
1865.			
January 10 to 19........	4 31.8 E.	4 31.7 E.	4
February 10 to 18.......	30.7	30.8	4
March 10 to 19..........	31.6	32.1	4
April 10 to 19...........	31.5	32.2	4
May 10 to 19............	32.9	33.3	4
June 10 to 20	30.8	31.5	4
July 10 to 19............	32.2	32.3	4
August 11 to 20.........	32.1	32.3	4
September 12 to 20......	30.5	31.2	4
October 11 to 20	29.0	29.8	4
November 10 to 19......	30.2	30.1	4
December 10 to 18	30.4	30.4	4
1866.			
January 11 to 18........	4 29.9 E.	4 29.9 E.	4
February 11 to 19......	29.8	29.8	4
March 11 to 20..........	29.3	30.2	4
April 11 to 17...........	28.8	29.5	4

Taking the weighted mean according to number of days of observation for the first year, and the monthly means for the other years, we obtain the following resulting declinations for each of the years of observation:

Epoch.	Magnetic declination.	Days of observation.
	° ′	
1860.7	4 46.6 E.	From 20 days of observations in February, March, June, and December.
1861.2	44.5 E.	From 11 days of observations in February, March, and April.
1862.7	39.9 E.	From 39 days of observations in May to December inclusive.
1863.5	36.8 E.	From 53 days of observations, monthly means.
1864.5	33.9 E.	From 51 days of observations, monthly means.
1865.5	31.5 E.	From 48 days of observations, monthly means.
1866.2	29.8 E.	From 16 days of observations in January, February, March, and April.

Annual effect of the secular change of the declination.

From the above table, we infer the mean declination $-4^\circ 37'.6$ for the mean epoch 1863.47; and, assuming the annual increase $= a = 3' + da$, we find, from the seven conditional equations,

$$\begin{aligned}
0 &= +\,0.69 - 2.77\,da \\
0 &= +\,0.09 - 2.27\,da \\
0 &= -\,0.01 - 0.77\,da \\
0 &= +\,0.71 + 0.03\,da \\
0 &= -\,0.61 + 1.03\,da \\
0 &= -\,0.01 + 2.03\,da \\
0 &= +\,0.39 + 2.73\,da
\end{aligned}$$

the normal equation

$$0 = -\,1.67 + 26.04\,da$$

hence,

$$da = +0'.06 \text{ and } a = +\,3'.06$$

Supposing the secular change uniform, and the annual variation of small amount, the formula

$$D = -\,4^\circ\,37'.6 + 3'.06\,(t - 1863.47)$$

represents the observations quite satisfactorily; the computed values in the order of time being $-\,4^\circ\,46'.1$, $-\,4^\circ\,44'.5$, $-\,4^\circ\,40'.0$, $-\,4^\circ\,37'.5$, $-\,4^\circ\,34'.4$, $-\,4^\circ\,31'.4$, and $-\,4^\circ\,29'.2$ respectively.

The annual change deduced from the differential observations discussed further on is,

$$a = +\,3'.07$$

This value is slightly affected by development of torsion in the suspension-skein; its value for successive years showing a diminution.

Annual variation of the declination.

4° + minutes in table (E.).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	′	′	′	′	′	′	′	′	′	′	′	′
1860	......	57.0	44.2	......	......	45.9	......	......	......	......	......	45.4
1861	......	44.7	44.5	44.4	......	......	......	......	......	......	......	......
1862	......	......	......	......	40.6	40.3	40.1	40.4	40.7	39.6	39.1	38.7
1863	38.3	37.5	37.8	37.8	37.4	37.5	37.3	36.5	36.8	35.3	35.2	34.7
1864	34.1	34.8	34.6	34.7	34.3	34.7	33.7	35.1	34.6	32.5	32.0	32.2
1865	31.7	30.8	32.1	32.2	33.3	31.5	32.3	32.3	31.2	29.8	30.1	30.4
1866	29.9	29.8	30.2	29.5	......	......	......	......	......	......	......	......

It is best to average the above for four full years commencing with May:

Year.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.
	′	′	′	′	′	′	′	′	′	′	′	′
1862.3	40.6	40.3	40.1	40.4	40.7	39.6	39.1	38.7	38.3	37.5	37.8	37.8
1863.4	37.4	37.5	37.3	36.5	36.8	35.3	35.2	34.7	34.1	34.8	34.6	34.7
1864.5	34.3	34.7	33.7	35.1	34.6	32.5	32.0	32.2	31.7	30.8	32.1	32.2
1865.6	33.3	31.5	32.3	32.3	31.2	29.8	30.1	30.4	29.9	29.8	30.2	29.5
Mean	36.4	36.0	35.9	36.1	35.8	34.3	34.1	34.0	33.5	33.2	33.7	33.6
Correction for secular change.	−1.4	−1.1	−0.9	−0.6	−0.4	−0.1	+0.1	+0.4	+0.6	+0.9	+1.1	+1.4
[34.7]	35.0	34.9	35.0	35.5	35.4	34.2	34.2	34.4	34.1	34.1	34.8	35.0
Differ. from mean.	−0.3	−0.2	−0.3	−0.8	−0.7	+0.5	+0.5	+0.3	+0.6	+0.6	−0.1	−0.3

A + sign indicates deflection from the normal position to the west.
A − sign indicates deflection from the normal position to the east.

During the colder part of the year, the needle is deflected to the west; during the warmer part, to the east; with a total range of nearly 1′.3.

In the following table, I have collected for comparison the results for annual variation of the declination for some stations near our Atlantic coast.

The results for Washington, D. C., are combined from observations by Lieut. J. M. Gilliss, U. S. N., made on Capitol Hill* during 1840, 1841, and 1842, and my own observations during 1867 and 1868, not far from Lieutenant Gilliss' location (Coast Survey Report for 1869, p. 203). Their relative weights are 10 to 1; his observations being daily, mine only for three days each month.

The results for Philadelphia are from Coast Survey Report for 1860, p. 311, and for the stations Toronto,† Canada, and Eastport, Me., from Coast Survey Report for 1865, p. 170.

Observed annual variation of the declination at stations near our Atlantic seaboard.

+ indicates deflection to the west. — indicates deflection to the east.

Months.	Key West, 1862-1866, 4 years.	Washington, 1840-1842, 1867-1868, 4 years.	Philadelphia, 1840-1845, 5 years.	Toronto, 1845-1851, 7 years.	Toronto, 1856-1864, 9 years.	Toronto, 1865-1871, 7 years.	Toronto mean, 1845-1871, 23 years.	Eastport, 1860-1864, 4 years.	Weighted mean, 1840-1871, 40 years.
	′	′	′	′	′	′	′	′	′
January	+0.6	−0.6	+0.5	+0.1	+0.0	0.0	0.0	+0.1	+0.1
February	+0.6	−0.3	+0.4	−0.5	−0.1	+0.2	−0.1	−0.3	−0.0
March	−0.1	−0.2	−0.1	−0.2	+0.1	−0.3	−0.1	−0.4	−0.1
April	−0.3	+0.1	−0.1	−0.0	−0.1	+0.2	0.0	+0.2	−0.0
May	−0.3	+0.4	+0.2	−0.1	−0.5	−0.2	−0.3	−0.9	−0.2
June	−0.2	+0.1	−0.6	−0.5	−0.3	−0.7	−0.5	−0.8	−0.4
July	−0.3	−0.2	−1.0	−0.8	−0.1	−0.4	−0.4	−1.3	−0.5
August	−0.8	−0.7	−0.9	−0.2	+0.1	+0.1	0.0	+0.5	−0.2
September	−0.7	+0.4	−0.0	+0.7	+0.4	+0.1	+0.4	+0.6	+0.3
October	+0.5	+0.2	−0.2	+1.0	+0.2	+0.5	+0.6	+0.4	+0.4
November	+0.5	+0.2	+0.9	+0.3	+0.3	+0.4	+0.4	+1.9	+0.6
December	+0.3	+0.3	+0.7	+0.3	+0.0	−0.1	+0.1	+0.2	+0.2

There being at present no indication of a periodic change in the annual variation, nor a dependence on the amount of secular change, the column of mean values may be taken to represent fairly the law for our stations: it is the same as for Kew, St. Helena, Cape of Good Hope, and Hobarton.‡ The average annual range is about 1′.2; and, roughly speaking, the north end of the magnet is deflected to the east when the sun is north of the equator, and deflected to the west when south of the equator.

* Pub. Doc. (Senate), 2d sess, 28th Cong., 1844–45, vol. x, Doc. No. 172, Washington, 1845.

† Toronto Magnetic Observations, vols. 1 and 2, and pamphlet on Monthly Absolute Values from 1856 to 1864, by G. T. Kingston, director of observatory. The two columns for 1865–71 and for mean were added while this report was going through the press; see abstracts and results of magnetical and meteorological observations at the Magnetic Observatory, 1841 to 1871, inclusive, Toronto, 1875.

‡ Terrestrial and Cosmical Magnetism, by E. Walker, M. A., Cambridge, 1866, p. 76. The apparently anomalous character of the Dublin results would seem to be due to the disturbing effect of change of torsion, the same as noticed in the differential observations at Key West.

Abstract of monthly values for magnetic dip at Key West.

The mean result from February to June (inclusive), 1860, refer to needles 1 and 2 of dip-circle No. 9; those for August and December to needles 1 and 2 of dip-circle No. 8, as well as those for January, March, and May, 1861. In March, 1860, observations were made on two days; in December, 1860, on five days; in January, 1861, on three, in March, on four, and in May, on three days; in the remaining four months, on one day each. From May, 1862, to the close of the series, needles Nos. 1 and 2 of dip-circle No. 9 were used regularly on four days each month (about the middle).

$54° +$ minutes in table.

Months.	1860.	1861.	1862.	1863.	1864.	1865.	1866.
	′	′	′	′	′	′	′
January	....	36.4	....	34.0	30.1	28.5	26.4
February	42.3	....	....	32.2	28.8	26.6	28.8
March	37.4	36.9	....	30.9	25.2	27.5	29.2
April	....	....	....	31.1	27.0	29.9	30.3
May	38.7	37.0	29.9	32.2	28.4	29.9	....
June	35.8	....	28.0	30.3	30.1	27.5	....
July	....	....	30.1	30.8	30.3	29.3	....
August	35.4	....	31.1	30.0	29.2	29.7	....
September	....	....	30.2	30.7	28.3	29.9	....
October	....	....	32.3	31.1	30.4	31.1	....
November	....	....	32.8	29.7	30.7	28.0	....
December	37.3	....	33.4	31.1	29.6	27.2	....
Annual mean	37.8	36.8	31.0	31.2	29.0	28.8	28.7

Annual effect of the secular change in the dip.

The average dip referring to the epoch 1863.44 is $54° 31'.9$. By the aid of seven conditional equations, we obtain the annual change $\Delta\theta = -1'.6$; hence the dip for any time between 1860 and 1866,

$$\theta = +54° 31'.9 - 1'.6 (t - 1863.4)$$

The computed values for the respective epochs in the order of time are as follows: $54° + 36'.6$, $35'.4$, $33'.0$, $31'.7$, $30'1.$, $28'.5$, and $27'.4$ respectively.

For comparison with other stations, it may be noted that at Washington the dip also diminished between 1860 and 1866 at an average annual rate of $1'.1$ (Coast Survey Report for 1870, p. 108); at Toronto, the annual diminution between 1860 and 1866 was $0'.9$; and, at Eastport, between 1860 and 1864, it was $1'.7$.

Respecting the annual variation in the dip at Key West, our series is too much broken and too short to yield any result. At Toronto, the range of the annual variation appears to be about $2'$; the dip being less in summer and greater in winter.*

* E. Walker, Terrestrial and Cosmical Magnetism, 1866, p. 177.

Abstract of monthly values for horizontal magnetic intensity at Key West.

For December, 1860, January, March, and May, 1861, magnet C_6 was used in the measures for intensity; but, before and after this interval, magnet II was employed. The number of determinations for the horizontal force generally embrace several days each month. From May, 1862, to the close of the series, the observations regularly extend over four days, with morning and afternoon sets, giving eight values for the horizontal force each month. Oscillations and deflections being taken, the magnet moment of the magnet was also deduced. The units of measure are the grain and the foot.

A correction of $+0.013$ has been applied to the values resulting from C_6 in order to make the results homogeneous with those from magnet II. This correction was deduced from comparisons of values in March and May. The value 6.729 for February, 1860, is omitted from the table for want of accord.

Months.	1860.	1861.	1862.	1863.	1864.	1865.	1866.
January	....	6.753	....	6.739	6.741	6.733	6.728
February	....	....	....	6.742	6.741	6.741	6.726
March	6.756	6.745	....	6.743	6.743	6.738	6.722
April	....	....	....	6.739	6.743	6.732	6.725
May	6.751	6.749	6.741	6.739	6.742	6.724	....
June	6.756	....	6.746	6.740	6.733	6.727	....
July	....	....	6.744	6.740	6.735	6.726	....
August	....	....	6.743	6.740	6.735	6.725	....
September	....	....	6.743	6.738	6.737	6.727	....
October	....	....	6.738	6.736	6.730	6.723	....
November	....	....	6.743	6.737	6.734	6.728	....
December	6.746	....	6.737	6.742	6.738	6.730	....
Year	6.752	6.749	6.742	6.740	6.738	6.729	6.725
			+ 2				− 2
			6.744 For 1862.5				6.723 For 1866.5

The average horizontal force $H = 6.739$, answers for the middle epoch 1863.5.

Annual effect of the secular change in the horizontal intensity.

Comparing each annual mean with the above value of H, and forming conditional equations, we find the annual change of H, viz, $\Delta H = -0.0046$, equal to $-\frac{1}{1500}$ of H nearly.

The horizontal force at Key West, between 1860 and 1866, may be expressed by

$$H = 6.739 - 0.0046\ (t - 1863.5)$$

The diminution of the horizontal force is small, yet sufficiently well indicated. It is, however, contrary to the observed effect at Washington, where $\Delta H_{1863.5} = +\frac{H}{860}$, the increase having commenced about 1853. For Toronto, we have $\Delta H_{1863.5} = +\frac{H}{1500}$, with the minimum epoch 1860. At Eastport, H appears to have reached a minimum about 1862 (Coast Survey Report for 1865, pp. 172–173). It is therefore probable that at Key West the horizontal force is tending toward a minimum value.

Annual variation in the horizontal intensity.

Arranging the value of H between May, 1862, and April, 1866, inclusive, and taking the means of corresponding months, we find them to be as follows:

		Correction for secular change.			Correction for secular change.
1862,'63,'64,'65, May	6.737	−.002	1862,'63,'64,'65, November	6.735	....
June	6.736	−.002	December	6.737	+.001
July	6.736	−.001	1863,'64,'65,'66, January	6.735	+.001
August	6.736	−.001	February	6.737	+.001
September	6.736	−.001	March	6.737	+.002
October	6.732	....	April	6.735	+.002

The mean value being 6.736, the indications of an annual variation are a slight increase of H between December and April, and a slight decrease between May and November, but the series is too short to be trusted for so small a range as .006, or $\frac{H}{1100}$; moreover, at Philadelphia, Toronto, and Eastport, the horizontal force is greater in summer than in winter.

The resulting absolute measures for the magnetic declination, dip, and intensity are given in the following table, reduced, if not already referring to the middle of each year. The vertical force is found by $V = H \operatorname{cosec} \theta$, and the total force by $F = H \sec \theta$.

General table of results from absolute measures of the magnetic declination, dip, and intensity.

Epoch.	D	θ	H	V	F
	° ′	° ′			
1860.5	−4 47.2	54 37.8	6.752	8.280	11.665
1861.5	43.6	36.3	.748	.278	.650
1862.5	40.5	31.3	.744	.282	.620
1863.5	36.8	31.2	.740	.277	.612
1864.5	33.9	29.0	.738	.278	.598
1865.5	31.5	28.8	.729	.267	.582
1866.5	−4 28.9	54 28.2	6.723	8.261	11.569

The vertical and total forces appear to diminish slowly. The total force at Washington about 1863 was very slightly increasing, at Toronto it was stationary, and at Eastport* diminishing, as at Key West.

The differential measures of the changes in the magnetic declination from Brooke's automatic registration at Key West, 1860–66.

The following tables contain the hourly (Key West mean time) readings of the photographic traces of the unifilar declinometer, combined into monthly mean values.

The tabular numbers are expressed in scale-divisions, counting from an arbitrary zero, one division of the scale being 1′, or, with consideration of the torsion of the suspension-skein, 1′.008. *Increasing* scale-divisions correspond to *increasing east* declination.

Occasional failures in traces (whole days) or parts of traces (one or more hours) are not further noticed, since they can but little affect the monthly means. For the month of November, 1865, a special correction of −2.68 divisions † became necessary, and the hourly means set down in the table are so corrected. The cause of this disturbance does not clearly appear in the record, but seems to be connected with the landing of heavy guns in the vicinity of the observatory, and their subsequent transportation past the observatory.

*Coast Survey Report for 1865, p. 173.

† It is found as follows: Five preceding years give difference between October and November means −.46 divisions; hence, for November, 1865, 50.39 − 0.46 = 49.93; similarly, from the difference of the November and December means, 50.16 − 0.08 = 50.08. The mean 50.01 is the interpolated value for November, 1865. The observed mean value is 52.69; hence the correction given above

Monthly means of hourly readings from the photographic traces of the fixed declinometer at Key West.

Months.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	Noon.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	Midn't.	Mean.
1860.																									
January	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	......
February	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	......
March	70.3	70.0	70.3	69.9	70.1	70.1	71.0	72.9	73.1	72.3	71.5	69.7	68.0	67.2	66.9	67.7	68.1	68.6	68.8	69.3	70.0	70.3	70.2	70.3	69.86
April	68.8	68.7	68.9	69.1	68.7	69.6	71.1	71.6	71.4	69.6	67.9	66.2	64.9	64.5	64.8	65.6	67.0	67.6	67.8	68.1	68.3	68.8	69.1	69.1	68.22
May	67.4	67.5	67.5	67.7	68.0	69.2	71.0	71.0	69.5	67.2	65.1	64.3	63.5	63.7	64.5	65.7	66.5	66.3	66.1	66.2	66.7	66.9	67.1	67.2	66.91
June	66.3	66.2	66.5	66.8	67.2	68.8	70.1	70.0	68.1	66.4	64.3	62.9	62.5	62.5	63.3	64.3	65.1	65.5	65.6	65.7	66.0	65.8	66.1	66.4	65.93
July	66.0	66.1	66.3	66.5	67.0	68.3	69.9	69.6	68.6	67.1	65.0	63.2	62.5	62.1	62.5	63.7	64.5	65.0	65.1	65.1	65.5	66.1	66.0	66.0	65.73
August	65.5	65.5	65.5	65.8	66.2	68.0	71.5	70.8	70.0	66.5	63.2	61.8	61.2	61.0	62.2	63.7	64.6	64.9	64.9	65.1	65.3	65.6	65.2	65.3	65.38
September	65.5	65.8	66.0	66.1	66.3	67.6	69.9	70.2	68.3	66.0	64.0	62.5	61.9	62.4	63.4	64.4	64.3	64.4	64.6	65.2	65.1	65.1	64.8	65.3	65.38
October	65.3	65.2	65.2	65.6	65.6	65.8	67.0	68.0	68.0	66.4	64.8	63.8	63.2	63.3	63.6	63.6	64.0	64.3	64.4	64.8	65.1	65.1	65.0	65.2	65.10
November	64.4	64.3	64.2	64.4	64.8	64.8	65.6	66.6	66.8	65.8	64.0	62.8	62.1	62.4	62.8	63.1	63.6	63.9	64.3	64.8	64.9	64.7	64.9	64.5	64.35
December	64.1	64.2	64.5	64.5	64.6	64.8	65.0	66.0	66.7	66.5	65.2	63.7	62.8	62.7	63.2	63.6	63.9	64.1	64.3	64.7	64.9	64.7	64.5	64.2	64.48
1861.																									
January	64.0	63.9	63.9	64.1	64.1	64.6	64.3	65.7	66.9	66.9	65.3	63.5	62.3	61.9	62.5	63.0	63.4	63.5	64.0	64.3	64.6	64.6	64.4	64.3	64.17
February	63.6	63.6	63.6	63.6	63.7	63.6	64.1	65.4	66.8	66.8	65.9	63.8	62.2	61.5	61.3	61.9	62.4	62.8	63.1	63.6	64.1	64.0	64.1	64.0	63.73
March	63.6	63.7	63.9	63.8	63.9	64.4	65.8	67.0	66.9	65.8	64.0	61.9	60.7	60.4	60.8	61.9	62.5	62.6	62.5	63.0	64.2	63.8	63.7	63.7	63.52
April	62.9	63.2	63.4	63.4	63.4	64.4	65.9	66.5	66.0	64.3	62.8	61.2	59.6	58.9	59.2	60.4	61.7	62.2	62.4	62.3	62.8	62.8	62.9	62.9	62.73
May	63.3	63.3	63.1	63.5	63.6	64.9	66.4	66.6	65.5	63.9	62.3	61.1	60.5	60.0	60.2	60.8	61.8	62.4	62.6	62.7	62.7	62.9	63.2	63.2	62.94
June	61.9	61.8	61.8	62.5	63.1	64.2	66.1	66.3	65.3	63.5	61.6	60.2	59.3	59.0	59.3	60.0	60.8	61.5	61.5	61.7	61.7	62.0	62.2	61.9	62.05
July	61.8	62.0	62.0	62.4	62.9	64.2	65.7	65.6	64.3	62.2	60.5	59.6	59.2	59.4	59.7	60.5	61.2	61.5	61.7	61.7	61.7	61.9	62.0	62.1	61.91
August	62.7	63.0	62.4	63.0	63.5	64.7	67.0	67.1	65.2	62.5	60.2	59.0	58.5	58.6	59.4	60.4	61.3	61.8	61.9	62.2	62.1	62.6	62.7	62.6	62.27
September	61.7	62.0	62.3	62.5	62.7	64.0	66.0	66.0	64.7	62.1	59.9	58.5	58.2	58.7	59.6	60.7	61.1	61.2	61.4	61.7	61.6	61.7	61.7	61.7	61.74
October	61.9	61.7	61.6	61.9	62.0	62.5	64.1	64.5	64.2	62.8	61.3	59.9	59.9	60.2	60.6	60.9	60.9	60.9	61.6	61.8	61.9	62.1	62.0	61.9	61.80
November	60.9	60.9	60.7	60.9	61.0	61.1	61.7	62.8	63.4	63.0	61.6	60.3	59.3	59.3	59.6	60.0	60.4	60.6	61.0	61.3	61.4	61.4	61.3	61.1	61.04
December	61.1	60.8	60.9	60.8	60.9	60.8	61.0	62.3	63.4	64.2	63.6	62.1	60.8	59.8	59.4	59.6	60.4	61.0	61.3	61.5	61.7	61.7	61.4	61.3	61.32
1862.																									
January	61.2	60.9	60.9	60.7	60.6	60.7	60.9	62.0	64.1	65.0	64.2	61.9	59.9	58.8	58.3	58.8	59.9	60.4	60.8	61.2	61.4	61.4	61.6	61.4	61.13
February	60.9	60.9	60.9	61.1	61.3	61.3	61.6	62.8	63.3	63.0	61.4	60.0	59.2	59.3	59.6	60.1	60.2	60.1	60.3	60.7	60.7	60.8	60.7	60.5	60.86
March	60.0	60.2	60.3	60.5	60.5	60.9	62.4	62.9	62.6	61.9	60.6	59.4	58.3	58.0	58.5	59.3	59.7	59.8	59.8	60.0	60.1	60.1	60.2	60.2	60.27
April	60.0	60.4	60.5	60.4	60.6	61.3	62.7	62.9	61.8	60.4	58.6	57.3	56.5	56.7	57.4	58.4	59.3	59.4	59.8	59.6	59.8	60.0	60.1	60.2	59.75
May	59.7	59.8	59.9	59.8	60.4	61.4	62.6	62.4	60.8	58.8	57.1	56.2	56.0	56.4	56.8	57.7	58.4	58.9	58.9	59.2	59.5	59.3	59.5	59.6	59.13
June	59.8	59.8	60.0	60.0	60.5	61.6	63.0	63.5	62.4	60.8	59.0	57.6	56.8	56.6	56.7	57.4	58.3	59.0	59.2	59.2	59.2	59.6	59.7	59.8	59.56
July	59.4	59.3	59.4	59.6	60.2	61.8	62.9	62.7	61.7	60.0	58.6	57.6	56.9	56.4	56.6	57.4	58.1	58.8	58.6	59.0	59.0	59.2	59.3	59.4	59.25
August	59.2	59.3	59.1	59.2	59.8	61.5	63.3	63.1	61.7	59.3	57.4	56.2	55.7	55.8	56.6	57.5	58.1	58.2	58.8	58.9	59.4	59.5	59.1	59.1	58.99
September	58.6	58.8	58.9	59.2	59.1	60.4	62.5	63.1	62.1	60.1	57.9	56.5	55.7	55.7	56.5	57.4	57.9	58.3	58.4	58.4	58.6	58.7	58.4	58.7	58.75
October	58.7	58.9	58.5	58.3	58.2	58.9	60.5	61.1	60.8	59.4	58.1	57.0	56.6	56.9	56.8	57.4	57.3	57.9	58.4	59.2	59.0	58.8	59.2	58.9	58.53
November	57.8	57.6	58.1	58.2	58.1	58.4	58.8	59.2	59.6	59.2	58.2	57.4	57.1	57.2	57.3	57.5	57.8	58.4	58.4	58.6	58.5	58.5	58.2	58.0	58.17
December	57.9	57.6	57.5	57.8	57.9	57.6	58.1	59.2	60.1	60.5	59.7	58.2	56.9	56.4	56.4	56.9	57.6	58.2	58.6	58.8	59.1	58.7	58.5	58.1	58.18
1863.																									
January	57.4	57.4	57.3	57.3	57.5	57.5	58.2	59.7	61.2	61.0	58.6	56.5	55.5	55.5	56.0	56.8	57.1	57.4	57.8	58.2	58.8	58.3	58.1	58.0	57.80
February	57.4	57.0	57.1	57.2	57.0	57.2	57.3	58.5	59.4	59.6	59.1	57.7	56.6	56.0	55.8	56.2	56.5	57.0	57.4	57.7	57.8	57.7	58.1	57.8	57.46
March	56.9	56.8	56.9	57.1	57.2	57.6	58.7	59.4	59.4	58.5	57.3	55.7	54.5	54.3	54.7	55.4	55.8	56.1	56.1	56.5	56.8	56.9	56.9	56.8	56.76
April	56.7	56.6	56.8	56.9	56.9	57.4	58.8	59.2	58.7	57.6	56.3	55.1	54.1	53.9	54.2	54.9	55.5	55.8	56.6	56.2	56.3	56.6	56.8	56.7	56.44
May	56.4	56.5	56.5	57.0	57.1	58.3	59.8	59.9	59.1	57.6	56.1	54.9	54.3	54.0	54.0	54.8	55.5	55.8	56.0	56.3	56.5	56.7	56.7	56.5	56.51
June	56.0	55.9	56.2	56.4	57.0	58.1	59.1	59.1	57.9	56.5	55.3	54.3	53.9	53.9	54.2	54.8	55.3	55.7	55.7	55.8	56.1	56.4	56.5	56.2	56.10
July	55.9	55.9	55.8	56.1	56.3	57.9	59.1	59.5	58.2	56.9	55.6	54.6	54.1	53.9	54.0	54.4	54.9	55.4	55.3	55.6	55.7	56.4	56.2	56.1	55.99
August	55.9	55.9	55.7	55.8	56.4	57.6	59.8	59.6	58.2	55.9	54.4	53.4	53.0	53.1	53.6	54.4	55.0	55.3	55.3	55.4	55.8	55.7	55.9	55.8	55.70
September	55.1	55.7	56.1	56.1	56.6	57.5	58.7	58.9	58.0	56.5	54.6	53.5	53.1	53.3	54.1	54.9	55.2	55.3	55.3	55.9	56.0	55.6	55.6	55.5	55.71
October	55.4	55.0	55.0	55.0	55.0	55.8	57.3	57.6	56.8	55.7	54.6	54.0	54.0	54.1	54.3	54.3	54.4	54.8	55.0	55.1	55.6	55.3	55.4	55.4	55.20
November	54.5	53.9	54.4	54.4	55.1	54.9	55.4	56.3	56.4	56.3	55.2	54.4	54.2	54.1	54.0	54.2	54.7	55.1	55.5	55.6	55.8	55.5	55.3	54.9	55.00
December	54.4	54.2	54.0	54.2	54.3	54.4	54.3	54.9	56.1	56.9	56.8	55.7	54.8	54.1	53.7	54.0	54.8	55.3	55.5	55.7	55.5	55.3	55.0	54.8	54.95
1864.																									
January	54.1	53.8	53.7	54.0	54.1	54.3	54.2	55.4	56.7	57.8	57.0	54.8	53.3	52.7	52.5	53.4	54.2	54.5	55.0	55.2	55.1	55.0	54.8	54.4	54.58
February	53.9	53.8	53.7	53.8	54.0	54.2	54.1	55.0	55.9	56.4	56.0	55.0	54.0	53.4	53.1	53.2	53.5	53.8	54.2	54.5	54.4	54.4	54.3	54.1	54.22
March	53.8	53.6	53.7	54.0	54.4	54.5	55.6	56.0	56.0	55.3	54.3	53.2	52.4	52.2	52.5	53.1	53.4	53.4	53.6	53.8	54.1	53.9	54.1	53.8	53.95
April	53.5	53.3	53.3	53.6	54.1	54.4	55.4	55.4	54.6	53.8	53.0	52.6	51.8	51.5	51.6	51.9	52.8	53.3	53.3	53.9	53.5	53.5	53.4	53.3	53.33
May	53.0	53.0	53.3	53.3	53.6	54.2	55.1	55.2	54.6	53.4	52.2	51.3	51.0	50.9	51.1	51.7	52.3	52.7	52.9	52.8	52.9	52.8	53.0	53.2	52.90
June	53.8	54.0	54.3	54.1	54.3	55.5	56.6	56.9	56.1	54.5	52.8	51.4	50.8	50.7	51.0	51.6	52.3	52.8	53.2	53.5	53.8	53.7	53.7	53.9	53.55
July	53.3	53.2	53.1	53.0	53.6	54.7	55.9	55.9	55.0	53.4	51.9	51.1	50.7	50.6	50.8	51.3	51.9	52.4	52.9	52.9	53.2	53.3	53.4	53.6	52.96
August	53.2	52.9	53.3	53.5	53.9	55.3	57.1	56.3	54.6	52.7	51.2	50.4	50.1	50.3	50.9	51.9	52.3	52.5	53.0	53.3	53.4	53.4	53.4	53.4	53.01
September	52.8	52.9	53.1	53.2	53.2	54.4	55.8	55.2	53.7	52.1	50.9	50.2	50.3	51.0	51.7	52.5	53.0	53.1	53.2	53.2	53.1	52.9	52.8	52.6	52.79
October	52.6	52.6	52.6	52.5	52.3	53.1	54.0	54.0	53.5	52.5	51.4	50.9	51.3	51.7	52.2	52.3	52.5	52.9	53.5	53.1	53.2	53.0	53.0	52.8	52.64
November	52.2	51.9	52.0	52.1	52.3	52.6	53.2	54.0	54.1	53.3	52.4	51.1	50.9	50.9	51.3	51.6	52.0	52.3	52.8	52.9	53.0	53.2	52.8	52.5	52.39
December	52.2	51.9	52.0	52.2	52.3	52.4	52.3	53.4	54.6	54.0	52.5	51.2	50.8	50.8	51.4	51.9	52.2	52.6	52.9	53.1	53.1	53.1	52.4	52.6	52.41

Monthly means of hourly readings, etc.—Continued.

Months.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	Noon.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	Midn't.	Mean.
1865.																									
January	51. 7	51. 8	52. 0	52. 1	51. 9	52. 1	52. 3	52. 6	53. 1	52. 5	51. 6	50. 9	51. 0	51. 3	51. 4	51. 6	51. 8	52. 2	52. 5	53. 0	52. 8	52. 5	52. 0	51. 9	52. 03
February	51. 7	51. 8	51. 9	51. 9	51. 8	52. 0	52. 0	52. 1	52. 1	51. 5	51. 0	50. 7	50. 7	50. 6	50. 7	50. 8	50. 9	51. 2	51. 8	52. 6	52. 0	52. 1	52. 0	51. 9	51. 57
March	52. 0	51. 8	51. 8	52. 0	52. 1	52. 3	53. 4	54. 0	53. 3	52. 4	51. 3	50. 3	49. 7	49. 6	49. 9	50. 5	50. 8	51. 0	51. 2	51. 6	51. 8	51. 8	51. 7	51. 9	51. 59
April	51. 4	51. 7	51. 9	52. 1	52. 3	53. 0	54. 0	53. 6	52. 5	51. 1	50. 0	49. 2	48. 8	48. 6	48. 7	49. 0	49. 6	50. 0	50. 4	50. 8	51. 0	51. 4	51. 5	51. 4	51. 00
May	51. 7	51. 6	52. 1	51. 9	52. 4	53. 7	54. 9	54. 9	53. 5	51. 6	50. 1	49. 4	48. 8	48. 9	49. 2	49. 8	50. 3	50. 8	50. 7	51. 1	50. 9	51. 1	51. 3	51. 4	51. 34
June	51. 2	51. 0	50. 9	51. 1	51. 7	52. 7	53. 9	54. 0	52. 9	51. 3	49. 9	48. 9	48. 5	48. 1	48. 4	49. 1	49. 7	50. 2	50. 3	50. 4	50. 9	50. 9	51. 1	50. 7	50. 74
July	50. 0	50. 0	50. 4	50. 3	50. 8	52. 4	53. 8	53. 8	52. 7	50. 7	49. 1	48. 0	47. 8	47. 7	48. 0	48. 6	49. 4	49. 8	49. 9	50. 1	50. 5	50. 6	50. 5	50. 2	50. 21
August	50. 6	50. 2	50. 5	51. 4	51. 3	52. 6	54. 4	54. 5	53. 1	51. 1	49. 6	48. 3	47. 7	47. 5	48. 3	49. 0	49. 9	50. 8	50. 8	51. 0	51. 0	51. 1	50. 8	50. 7	50. 68
September	50. 6	50. 9	51. 4	51. 4	51. 3	51. 9	53. 4	53. 3	52. 1	50. 5	48. 9	48. 2	48. 1	48. 5	49. 4	49. 9	50. 1	50. 5	50. 7	50. 7	51. 0	51. 0	50. 6	50. 4	50. 62
October	50. 6	50. 5	50. 6	50. 6	50. 2	50. 3	51. 3	51. 4	50. 8	49. 9	49. 0	48. 6	48. 9	49. 7	49. 9	50. 5	50. 5	50. 3	50. 8	50. 9	50. 9	51. 0	51. 0	51. 2	50. 39
November	49. 3	49. 0	48. 9	48. 7	49. 0	49. 1	49. 5	50. 4	51. 0	51. 0	50. 8	50. 3	50. 2	50. 3	50. 6	50. 9	50. 9	50. 7	50. 5	50. 4	50. 3	49. 7	49. 4	49. 1	50. 01
December	49. 7	49. 5	49. 4	49. 2	49. 5	49. 6	49. 6	50. 4	51. 7	52. 3	51. 8	50. 6	49. 8	49. 3	49. 1	49. 5	50. 0	50. 3	50. 4	50. 6	50. 6	50. 5	50. 4	50. 1	50. 16
1866.																									
January	49. 3	49. 1	48. 8	49. 0	49. 1	49. 0	49. 3	50. 4	51. 8	52. 5	51. 4	49. 4	48. 0	47. 5	47. 7	48. 4	49. 1	49. 5	49. 8	50. 2	50. 1	49. 9	49. 7	49. 4	49. 52
February	49. 4	49. 2	49. 3	48. 9	49. 0	48. 8	49. 0	49. 6	50. 5	50. 9	49. 9	48. 4	47. 4	47. 1	47. 2	47. 8	48. 3	48. 5	49. 0	49. 6	49. 9	49. 7	49. 2	49. 4	49. 00
March	47. 3	47. 2	47. 3	47. 7	48. 1	48. 4	49. 0	48. 8	48. 5	47. 8	46. 8	46. 3	46. 0	45. 9	46. 1	46. 8	46. 9	47. 5	47. 9	48. 0	48. 3	48. 0	47. 6	47. 4	47. 48

Recapitulation of monthly means of declinometer-readings.

Year.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.
1860–61	69. 86	68. 22	66. 91	65. 93	65. 73	65. 38	65. 38	65. 10	64. 35	64. 48	64. 17	63. 73
1861–62	63. 52	62. 73	62. 94	62. 05	61. 91	62. 27	61. 74	61. 80	61. 04	61. 32	61. 13	60. 86
1862–63	60. 27	59. 75	59. 13	59. 56	59. 25	58. 99	58. 75	58. 53	58. 17	58. 18	57. 80	57. 46
1863–64	56. 76	56. 44	56. 51	56. 10	55. 99	55. 70	55. 71	55. 20	55. 00	54. 95	54. 58	54. 28
1864–65	53. 95	53. 33	52. 90	53. 55	52. 96	53. 01	52. 79	52. 64	52. 39	52. 41	52. 03	51. 57
1865–66	51. 59	51. 00	51. 34	50. 74	50. 21	50. 68	50. 62	50. 39	50. 01	50. 16	49. 52	49. 00
1866	47. 48	......	......	......	......	......	......	......	......	......	......	......

Examination of the permanency in the direction of the line of detorsion in the suspension-skein.

Tabulating the annual means, March to February inclusive, and forming the differences, or the apparent effect of the secular change, we have:

		′
1860–61	— 65. 77	
		+ 3. 83
1861–62	— 61. 94	
		+ 3. 12
1862–63	— 58. 82	
		+ 3. 22
1863–64	— 55. 60	
		+ 2. 81
1864–65	— 52. 79	
		+ 2. 35
1865–66	— 50. 44	

While the apparent average annual diminution of the declination, +3′.07, agrees well with the (uniform) value +3′.06, given by the absolute measures, it is evidently subject to change, being in a state of diminution, quite rapid in the first five months. The torsion in the suspension-skein was therefore undergoing considerable change in the first five months, and had not come to a stationary condition even after the lapse of six years. That the permanency of the line of detorsion cannot be depended on during a year for measures involving so small an amount as a fraction of a minute appears from the consideration of the annual variation as made out from the above scale-readings

after omitting all of 1860 and of 1866. We find from the five complete years 1861 to 1865, during which the monthly effect of the apparent secular change amounted to $\frac{2.90}{12} = 0.24$ divisions:

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	′	′	′	′	′	′	′	′	′	′	′	′
1861–65............	57.94	57.58	57.22	56.65	56.56	56.40	56.06	56.13	55.92	55.71	55.32	55.40
Correction for secular change.	− 1.33	− 1.09	− 0.85	− 0.60	− 0.36	− 0.12	+ 0.12	+ 0.36	+ 0.60	+ 0.85	+ 1.09	+ 1.33
Corrected.........	56.61	56.49	56.37	56.05	56.20	56.28	56.18	56.49	56.52	56.56	56.41	56.73
Diff. from mean...	− 0.20	− 0.08	+ 0.04	+ 0.36	+ 0.21	+ 0.13	+ 0.23	− 0.08	− 0.11	− 0.15	− 0.00	− 0.32

A + sign indicating a deflection to the west, these numbers are contrary in sign to the true annual variation, and are therefore the effect of developed torsion, which, from the regularity of signs, appears to have an annual period depending on changes of moisture and of temperature.

Neither the effect of secular change nor of change of torsion need be further considered in the discussion of the *daily* variation.

To convert differential into absolute measures, we have, for the middle epoch of the whole series, the average reading of the scale 57.56, and the average declination computed for this epoch from the preceding formula —4° 38′.55; hence, very nearly, the relation 57 scale-divisions correspond to 4° 38′ east declination.

The direct monthly comparisons of the fixed and portable declinometers furnish very nearly the same relation.

Discussion of the disturbances of the magnetic declination.

If we recognize all deviations from the normal, belonging to a given time of the day, month, and year, which exceed a certain limit, as disturbances, we may determine that limit by the application of Peirce's criterion* for the rejection of doubtful observations. In this case, we must substitute, for "doubtful observations", the words "observations following a different law from that supposed by the theory of probability". It is evident that no strict limit can be given, since we have no means of identifying disturbances as such except by their apparent discord with the observations belonging to the same hour, month, and year. The disturbances, however, follow a sufficiently distinct law to render this a matter of small moment. To take account of the variability of the disturbances in the daily, annual, and seculiar periods, the limit of the criterion εx was determined from differences from the normals at 0^h a. m. in January, at 2^h a. m. in February, at 4^h a. m. in March, etc., and at 10^h p. m. in December, for each year separately. To save the trouble of squaring the differences v, the formula $\varepsilon^2 = 1.57 \frac{[v]^2}{n(n-1)}$ may be used in the place of $\varepsilon^2 = \frac{[v^2]}{n-1}$. From fifty-three months treated in this manner, the limiting deviation from the normals was found to be 2.6 scale, divisions, or minutes. In the discussion of the Girard College magnetic observations, where a similar process has been applied (Coast Survey Report for 1859, p. 280), the limit was 3′.6; and at Toronto General Sir E. Sabine raised the limit to 5′.0. It has already been indicated that the limit is a function of the eleven-year cycle.

* Coast Survey Report for 1854, pp. 131–138, and Gould's Astronomical Journal, No. 83, Cambridge, April 24, 1855. The criterion was first used for this purpose in my discussion of Dr. Kane's magnetic observations at Van Rensselaer Harbor, Smithsonian Contributions to Knowledge, vol. x, 1858.

All disturbances having been excluded, we find the normal means as given below:

Monthly normals of hourly readings of the declinometer at Key West, Fla.

Months.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	Noon.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	Midn't.
1860.																								
January	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
February	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
March	70.3	70.0	69.9	69.7	70.0	70.4	71.3	72.5	73.1	72.3	72.1	69.6	67.5	67.1	66.5	67.6	68.1	68.5	68.5	69.0	70.0	69.8	70.1	69.9
April	68.7	68.7	68.8	69.0	68.9	69.7	71.2	71.6	70.7	69.5	67.8	66.1	65.0	64.5	64.9	65.7	67.0	67.6	67.7	67.9	68.3	68.5	68.9	69.0
May	67.3	67.5	67.5	67.7	68.0	69.2	71.2	71.3	69.2	67.0	65.0	64.3	63.5	63.7	64.5	65.7	66.5	66.3	66.2	66.2	66.7	66.8	67.1	67.2
June	66.1	66.2	66.4	66.7	67.1	68.8	70.1	69.9	68.1	66.4	64.3	62.9	62.5	62.5	63.3	64.3	65.1	65.5	65.6	65.6	65.7	65.8	66.1	66.2
July	66.0	65.8	65.9	66.3	67.0	68.8	69.8	69.6	68.6	66.7	65.0	63.3	62.6	61.9	62.5	63.9	64.6	65.0	65.1	65.1	65.1	65.8	66.0	66.0
August	65.5	65.5	65.5	65.8	66.2	68.3	71.4	71.1	69.9	66.0	63.2	61.5	61.2	60.6	62.2	63.7	64.6	64.9	64.9	64.9	65.3	65.6	65.2	65.3
September	65.3	65.7	65.9	66.1	66.3	67.5	69.8	69.9	68.0	66.0	63.9	62.5	61.9	62.4	63.4	64.4	64.2	64.3	64.6	65.2	64.9	64.9	65.1	65.3
October	65.3	65.2	65.2	65.6	65.6	66.1	67.0	67.9	68.0	66.4	65.0	64.0	63.4	63.3	63.6	63.6	64.0	64.3	64.4	64.8	65.0	65.1	65.0	65.2
November	64.4	64.3	64.2	64.4	64.8	64.8	65.6	66.6	66.8	65.8	64.1	62.9	62.1	62.4	62.8	63.1	63.6	63.9	64.3	64.7	64.7	64.5	64.9	64.5
December	64.1	64.2	64.5	64.5	64.6	64.8	65.0	66.0	66.9	66.5	65.2	63.7	62.9	62.7	63.2	63.6	63.9	64.1	64.3	64.7	64.9	64.7	64.5	64.2
1861.																								
January	63.9	63.9	64.0	64.2	64.4	64.7	64.6	66.0	66.9	66.8	65.1	63.5	62.3	62.1	62.6	63.1	63.4	63.5	64.0	64.2	64.5	64.5	64.2	64.2
February	63.6	63.5	63.5	63.6	63.7	63.6	64.1	65.5	66.8	66.8	65.9	63.9	62.2	61.5	61.3	61.9	62.4	62.9	63.1	63.5	64.0	63.9	63.8	63.7
March	63.5	63.5	63.6	63.8	63.9	64.4	65.8	66.8	66.7	65.7	64.0	61.9	60.7	60.3	60.7	61.9	62.5	62.6	62.5	62.9	63.7	63.6	63.6	63.6
April	62.9	63.2	63.4	63.4	63.4	64.4	65.9	66.8	66.4	65.3	63.5	61.4	59.5	58.9	59.2	60.3	61.7	62.2	62.3	62.3	62.7	62.8	62.8	62.9
May	63.3	63.2	63.0	63.4	63.6	64.9	66.4	66.5	65.4	63.9	62.3	61.1	60.6	60.1	60.2	60.8	61.7	62.4	62.6	62.7	62.7	62.9	63.2	63.2
June	61.9	61.8	61.8	62.5	63.1	64.2	66.1	66.3	65.3	63.6	61.5	60.3	59.3	58.9	59.2	60.0	60.8	61.5	61.5	61.6	61.6	62.0	62.2	61.9
July	61.9	62.0	62.0	62.4	62.9	64.3	65.7	65.8	64.3	62.2	60.6	59.7	59.1	59.5	59.7	60.6	61.2	61.5	61.6	61.7	61.7	61.9	61.9	62.1
August	62.7	63.0	62.4	62.8	63.3	64.7	66.9	67.0	64.9	62.4	60.3	59.0	58.5	58.6	59.4	60.4	61.3	61.8	61.9	62.1	62.1	62.2	62.6	62.6
September	61.7	62.0	62.3	62.5	62.7	64.0	66.0	66.0	64.6	62.2	59.7	58.4	58.1	58.6	59.5	60.7	61.1	61.2	61.3	61.5	61.6	61.5	61.7	61.7
October	61.8	61.7	61.6	62.0	62.0	62.5	64.1	64.6	64.4	62.9	61.3	59.9	59.9	60.2	60.6	60.9	60.9	60.9	61.4	61.8	61.9	62.1	61.9	61.9
November	60.9	60.9	60.7	60.9	61.0	61.1	61.7	62.8	63.4	63.1	61.6	60.2	59.3	59.3	59.6	60.0	60.4	60.6	61.0	61.3	61.4	61.4	61.3	61.1
December	61.1	60.8	60.9	60.8	60.9	60.8	61.0	62.3	63.5	64.2	63.6	62.2	60.9	59.8	59.4	59.6	60.4	60.9	61.3	61.5	61.7	61.4	61.4	61.3
1862.																								
January	61.2	60.9	60.7	60.7	60.6	60.7	60.9	62.0	64.1	65.0	64.0	61.8	59.7	58.7	58.5	59.2	60.2	60.4	60.8	61.2	61.4	61.4	61.4	61.4
February	60.9	61.0	61.0	61.1	61.3	61.2	61.6	62.6	63.2	63.0	61.4	60.2	59.0	59.1	59.6	60.1	62.2	60.1	60.0	60.3	60.5	60.6	60.6	60.9
March	60.4	60.5	60.6	60.4	61.1	61.1	62.6	63.1	62.7	62.0	60.5	59.4	58.3	57.9	58.5	59.3	59.7	59.8	59.8	60.0	60.1	60.1	60.2	60.2
April	60.1	60.0	60.5	60.4	60.5	61.3	62.7	63.0	61.8	60.5	58.3	57.4	56.6	56.6	57.3	58.4	59.3	59.4	59.6	59.6	59.7	60.0	60.1	60.2
May	9.7	59.9	60.0	59.8	60.4	61.4	62.6	62.3	60.8	59.0	57.3	56.2	56.0	56.4	57.0	58.1	58.7	59.1	59.1	59.2	59.5	59.4	59.6	59.6
June	59.8	59.8	60.0	60.0	60.5	61.6	63.0	63.3	62.5	61.1	58.8	57.6	56.8	56.6	56.7	57.4	58.3	59.0	59.2	59.2	59.2	59.6	59.7	59.8
July	59.2	59.2	59.3	59.5	60.1	62.0	63.0	62.8	62.0	60.2	58.6	57.6	56.8	56.3	56.7	57.4	58.1	58.7	58.8	58.7	58.7	59.0	59.2	59.2
August	58.9	58.9	58.9	59.3	59.6	61.6	63.4	63.0	61.8	59.3	57.2	56.4	55.9	56.0	56.6	57.5	58.1	58.2	58.3	58.6	58.9	59.2	59.1	58.8
September	58.5	58.8	58.9	59.2	59.1	60.4	62.9	63.1	62.3	59.9	57.7	56.3	55.7	55.7	56.5	57.4	57.9	58.3	58.3	58.3	58.6	58.4	58.3	58.5
October	58.3	58.4	58.3	58.3	58.5	59.4	60.5	61.3	60.7	59.5	58.1	57.0	56.6	56.9	57.1	57.4	56.9	57.8	58.3	59.0	58.7	58.7	58.7	58.4
November	57.5	57.5	57.9	58.1	58.0	58.4	58.5	59.2	59.5	59.2	58.3	57.4	57.2	57.2	57.2	57.5	57.8	58.3	58.4	58.6	58.4	58.5	58.2	58.0
December	57.8	57.5	57.4	57.8	57.7	57.6	58.1	59.2	60.3	60.6	59.8	58.2	56.9	56.4	56.4	56.9	57.6	58.3	58.6	58.8	58.9	58.7	58.3	58.1
1863.																								
January	57.4	57.4	57.4	57.3	57.5	57.7	58.2	59.7	61.3	61.0	58.7	56.6	55.5	55.5	56.0	56.8	57.1	57.4	57.8	58.1	58.6	58.3	58.1	57.7
February	57.3	57.0	57.1	57.2	57.1	57.4	57.5	58.4	59.5	59.6	59.1	57.7	56.5	55.9	56.1	56.3	56.5	57.0	57.3	57.6	57.8	57.7	57.9	57.7
March	56.9	56.8	57.0	57.1	57.1	57.6	58.4	59.3	59.4	58.6	57.3	56.0	54.6	54.5	54.8	55.4	55.8	56.0	56.1	56.5	56.8	56.9	56.9	56.8
April	56.4	56.5	56.6	56.9	56.9	57.5	58.7	59.2	58.6	57.8	56.2	55.2	54.3	53.9	54.2	54.9	55.5	55.8	56.6	56.1	56.2	56.5	56.7	56.5
May	56.4	56.6	56.5	57.0	57.1	58.3	60.1	59.8	59.1	57.4	56.1	54.9	54.3	54.0	54.0	54.8	55.5	55.8	55.9	56.2	56.5	56.4	56.7	56.5
June	55.9	55.8	56.2	56.3	57.0	58.1	59.0	59.1	57.9	56.5	55.3	54.3	53.9	54.0	54.3	54.8	55.3	55.7	55.7	55.8	56.1	56.3	56.4	56.2
July	55.9	55.8	55.8	56.1	56.4	57.9	59.3	59.4	58.3	57.1	55.7	54.6	54.1	54.0	54.1	54.4	54.9	55.4	55.3	55.6	55.7	55.8	56.0	55.9
August	55.8	55.9	55.8	55.8	56.4	57.6	60.0	59.7	57.7	55.9	54.4	53.4	53.0	53.1	53.7	54.4	55.0	55.4	55.2	55.5	55.6	55.7	55.8	55.8
September	55.2	55.7	56.1	56.0	56.6	57.5	58.6	59.0	58.1	56.5	54.6	53.5	53.1	53.3	54.1	54.9	55.3	55.2	55.2	55.5	55.6	55.6	55.6	55.6
October	55.2	55.1	54.9	55.0	55.3	55.9	57.3	57.6	56.7	55.6	54.6	54.0	54.0	54.1	54.3	54.4	54.4	54.6	54.9	55.1	55.4	55.2	55.4	55.4
November	54.5	54.1	54.4	54.7	55.1	54.9	55.4	56.3	56.4	56.3	55.2	54.5	54.2	54.1	54.0	54.2	54.7	55.1	55.5	55.5	55.5	55.1	55.0	54.9
December	54.3	54.1	53.9	54.2	54.3	54.4	54.3	55.2	56.1	56.9	56.9	55.9	54.8	54.1	53.7	54.0	54.8	55.2	55.5	55.6	55.4	55.3	55.0	54.8
1864.																								
January	54.1	53.8	53.8	54.0	54.1	54.3	54.2	55.4	56.7	57.8	57.0	54.6	53.3	52.7	52.5	53.4	54.2	54.5	55.0	55.1	55.1	55.0	54.8	54.4
February	53.9	53.8	53.6	53.8	54.0	54.2	54.1	55.0	56.0	56.5	56.3	55.0	54.0	53.4	53.1	53.2	53.5	53.8	54.0	54.5	54.4	54.4	54.2	54.0
March	53.8	53.7	53.7	53.9	54.4	54.5	55.6	56.1	56.2	55.4	54.4	53.2	52.5	52.3	52.7	53.3	53.4	53.4	53.6	53.8	53.7	53.9	54.0	53.8
April	53.4	53.3	53.3	53.7	54.0	54.6	55.8	55.5	54.7	53.8	52.9	52.4	52.1	51.7	51.7	51.7	52.7	53.1	53.2	53.5	53.4	53.3	53.4	53.3
May	53.0	53.0	53.3	53.3	53.6	54.3	55.1	55.3	54.4	53.4	52.2	51.3	51.0	50.9	51.2	51.7	52.3	52.7	52.8	52.7	52.7	52.8	52.8	53.1
June	53.4	53.8	53.8	54.1	54.6	55.5	56.6	56.8	55.7	54.4	52.8	51.3	50.9	50.8	51.1	51.8	52.5	52.9	53.2	53.4	53.5	53.9	53.7	53.6
July	53.3	53.1	53.2	52.9	53.4	54.7	56.0	55.9	54.8	53.2	51.8	51.1	50.7	50.6	50.8	51.3	51.9	52.3	52.7	52.7	53.0	53.0	53.2	53.2
August	53.2	52.9	53.2	53.5	53.9	55.1	56.7	56.7	54.6	52.8	51.2	50.4	50.0	50.4	51.0	51.8	52.3	52.5	52.8	52.8	53.1	53.2	53.3	53.1
September	52.9	53.2	53.1	53.4	53.3	54.5	56.1	55.2	53.8	52.1	50.9	50.2	50.3	51.0	51.7	52.5	53.0	52.8	53.2	52.9	53.0	53.0	52.8	52.7
October	52.5	52.5	52.6	52.5	52.5	53.2	54.1	54.2	53.4	52.5	51.4	50.8	51.3	51.7	52.2	52.2	52.5	52.7	53.4	53.1	53.2	52.9	52.9	52.7
November	52.2	52.0	52.3	52.1	52.4	52.6	53.2	54.1	54.1	53.4	52.4	51.1	50.9	50.9	51.2	51.5	52.0	52.3	52.7	52.9	53.0	53.0	52.8	52.5
December	52.1	52.0	52.0	52.2	52.3	52.4	52.5	53.6	54.7	54.0	52.8	51.5	50.9	50.8	51.4	51.9	52.2	52.5	52.7	53.0	53.1	52.9	52.5	52.6

Monthly normals of hourly readings of the declinometer, etc.—Continued.

Months.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	Noon.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	Midn't.
1865.																								
January	51.8	51.8	52.0	52.1	51.9	52.2	52.3	52.5	53.1	52.6	51.6	50.7	51.0	51.3	51.4	51.6	51.8	52.1	52.4	52.4	52.6	52.5	52.0	51.9
February	51.6	51.6	51.8	51.8	51.8	52.0	52.3	52.3	52.1	51.7	51.2	50.7	50.7	50.7	50.7	50.8	50.9	51.2	51.8	52.0	51.9	52.1	51.9	51.8
March	51.7	51.8	51.8	52.0	52.1	52.3	53.5	53.9	53.3	52.4	51.4	50.3	49.8	49.6	50.0	50.5	50.8	51.0	51.2	51.6	51.7	51.8	51.6	51.8
April	51.4	51.5	51.9	51.9	52.2	53.0	54.0	53.7	52.5	51.1	50.0	49.2	48.8	48.6	48.7	49.0	49.6	50.0	50.3	50.7	51.0	51.1	51.3	51.3
May	51.6	51.5	51.7	51.8	52.3	53.7	54.9	54.9	53.6	51.5	49.9	49.1	48.9	48.9	49.3	49.9	50.5	50.7	50.7	50.8	50.8	51.1	51.3	51.4
June	51.0	51.0	50.9	51.1	51.7	52.7	53.9	54.0	52.8	51.2	49.9	48.9	48.5	48.1	48.4	49.1	49.7	50.2	50.2	50.4	50.7	50.5	50.7	50.6
July	49.9	50.5	50.5	50.5	50.8	52.5	53.8	53.8	52.7	50.9	49.1	48.0	47.8	47.8	48.1	48.6	49.4	49.8	49.9	50.1	50.5	50.5	50.5	50.2
August	50.3	50.1	50.4	50.6	51.1	52.2	54.5	54.6	53.4	51.4	50.0	48.7	47.9	47.9	48.4	49.0	50.1	50.5	50.7	50.5	50.6	50.4	50.2	50.4
September	50.7	50.9	51.2	51.4	51.2	51.9	53.2	53.3	52.0	50.7	49.1	48.4	48.0	48.5	49.4	49.9	50.1	50.2	50.3	50.4	50.6	50.7	50.6	50.5
October	50.6	50.7	50.6	50.6	50.3	50.4	51.7	51.8	50.9	49.9	49.0	48.6	48.9	49.7	49.9	50.5	50.3	50.3	50.5	50.9	50.9	50.9	50.7	51.0
November*	49.2	49.0	48.9	48.8	48.8	49.0	49.4	50.4	51.0	50.9	50.8	50.3	50.2	50.5	50.8	50.9	50.9	50.7	50.6	50.4	50.2	49.9	49.4	49.1
December	49.7	49.5	49.2	49.2	49.5	49.6	49.6	50.5	51.7	52.3	51.8	50.4	49.5	49.0	48.8	49.2	49.8	50.1	50.4	50.6	50.6	50.5	50.4	50.0
1866.																								
January	49.3	49.1	48.9	49.0	49.1	49.2	49.3	50.4	51.8	52.5	51.1	49.4	48.0	47.5	47.7	48.4	49.1	49.5	49.7	50.0	50.1	49.9	49.6	49.4
February	48.9	48.8	49.0	48.9	49.0	48.8	49.0	49.6	50.8	51.3	50.3	48.5	47.5	47.0	47.3	47.8	48.1	48.5	49.0	49.2	49.5	49.3	49.1	49.1
March	47.3	47.2	47.5	47.8	48.2	48.5	49.0	48.8	48.4	47.8	46.8	46.3	46.1	46.1	46.2	46.9	47.1	47.5	47.9	48.0	47.9	47.7	47.6	47.3

* The correction —2.68 divisions for this month, has been applied as before.

Mean monthly normals of hourly readings from observations extending over 6 years. *

Months.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	Noon.
1860 to 1865 inclusive.												
April	58.82	58.87	59.08	59.22	59.32	60.08	61.38	61.63	60.78	59.67	58.12	56.95
May	58.55	58.62	58.67	58.83	59.17	60.30	61.72	61.68	60.42	58.70	57.13	56.15
June	58.02	58.07	58.18	58.45	59.00	60.15	61.45	61.57	60.38	58.87	57.10	55.88
July	57.70	57.73	57.78	57.95	58.43	59.95	61.27	61.22	60.12	58.38	56.80	55.72
August	57.73	57.72	57.70	57.97	58.42	59.92	62.15	62.02	60.38	57.97	56.05	54.90
September	57.38	57.72	57.92	58.10	58.20	59.30	61.10	61.08	59.80	57.90	55.98	54.88
October	57.28	57.27	57.20	57.33	57.37	57.90	59.12	59.57	59.02	57.80	56.57	55.72
November	56.45	56.30	56.40	56.50	56.68	56.80	57.30	58.23	58.53	58.12	57.07	56.07
December	56.52	56.35	56.32	56.45	56.55	56.60	56.75	57.80	58.87	59.08	58.35	56.98
1861 to 1866 inclusive.												
January	56.28	56.15	56.13	56.22	56.27	56.47	56.58	57.67	58.98	59.28	57.92	56.10
February	56.03	55.95	56.00	56.07	56.15	56.20	56.43	57.23	58.07	58.15	57.37	56.00
March †	55.60	55.58	55.70	55.83	56.13	56.40	57.48	58.00	57.78	56.98	55.73	54.52

Months.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	Midn't.	Mean.
1860 to 1865 inclusive.													
April	56.05	55.70	56.00	56.67	57.63	58.02	58.28	58.35	58.55	58.70	58.87	58.87	58.57
May	55.72	55.67	56.03	56.83	57.53	57.83	57.88	57.97	58.15	58.23	58.45	58.50	58.28
June	55.32	55.15	55.50	56.23	56.95	57.47	57.57	57.67	57.80	58.02	58.13	58.05	57.96
July	55.18	55.02	55.32	56.03	56.68	57.12	57.23	57.32	57.45	57.67	57.80	57.77	57.65
August	54.42	54.43	55.22	56.13	56.90	57.22	57.30	57.40	57.60	57.72	57.70	57.67	57.61
September	54.52	54.92	55.77	56.63	56.93	57.00	57.15	57.30	57.38	57.35	57.35	57.38	57.46
October	55.68	55.98	56.28	56.50	56.50	56.77	57.15	57.45	57.52	57.48	57.43	57.43	57.26
November	55.65	55.73	55.93	56.20	56.57	56.82	57.08	57.23	57.20	57.07	56.93	56.68	56.81
December	55.98	55.47	55.48	55.87	56.45	56.85	57.13	57.37	57.43	57.25	57.02	56.83	56.91
1861 to 1866 inclusive.													
January	54.97	54.63	54.78	55.42	55.97	56.23	56.62	56.83	57.05	56.93	56.68	56.50	56.53
February	54.98	54.60	54.68	55.02	55.27	55.58	55.87	56.18	56.35	56.33	56.25	56.20	56.12
March †	53.67	53.45	53.82	54.55	54.88	55.05	55.18	55.47	55.65	55.67	55.65	55.58	55.60

* The mean epoch for the April normals is 1862.8; and for the March normals, 1863.8; average epoch, 1863.3.
† March, 1860, is less complete than March, 1866; the latter has therefore been retained in preference.

In the analysis of the disturbances, no attempt was made to correct for occasional deficiencies in the hourly record, as the necessary inferences would rest on too slender a basis; and, in their classification, the series was taken to commence with April, 1860, since March, 1860, is less complete than March, 1866.

The total number of disturbances, that is, hourly readings differing more than 2′.6 either in excess or defect from their respective normal values during the six years of observation, is 1432; and, since the total number of hourly observations is about 49250, there is one disturbance for every 34 observations.

The distribution of *disturbances* according to *number* is as follows:

During 6 years, April, 1860, to April, 1866, + or west deflections 614
During 6 years, April, 1860, to April, 1866, — or east deflections.......................... 818

The eastern deflections predominate over the western deflections in the proportion of 1.33 to 1.

Number of disturbances during six successive years.

Years.	West.	East.	Total.
1860–61........	70	140	210
1861–62........	82	69	151
1862–63........	136	161	297
1863–64........	84	110	194
1864–65........	117	160	277
1865–66........	125	178	303

The years 1860–61 and 1861–62 are those which are most defective in photographic traces. In the first, nearly 2000 hourly deficiencies occur; in the second, nearly 800. The record for the remaining four years is nearly complete.

The annual numbers do not indicate any dependence on the eleven-year cycle, even if the first two numbers were increased (for deficiencies). With the exception of the second year, the eastern deflections preponderate over the western ones.

Distribution of disturbances in the yearly period.

Months.	West.	East.	Total.	Ratios.		
				West.	East.	Total.
January	32	41	73	.63	.60	.61
February	57	58	115	1.12	.85	.95
March	54	47	101	1.06	.69	.85
April	69	85	154	1.35	1.25	1.29
May	56	60	116	1.09	.88	.97
June..................	24	58	82	.47	.85	.69
July	62	93	155	1.21	1.36	1.30
August	85	133	218	1.66	1.95	1.83
September	56	95	151	1.10	1.39	1.27
October...............	53	67	120	1.03	.99	1.01
November	33	42	75	.64	.62	.63
December	33	39	72	.64	.57	.60
Sum............	614	818	1,432	12.00	12.00	12.00

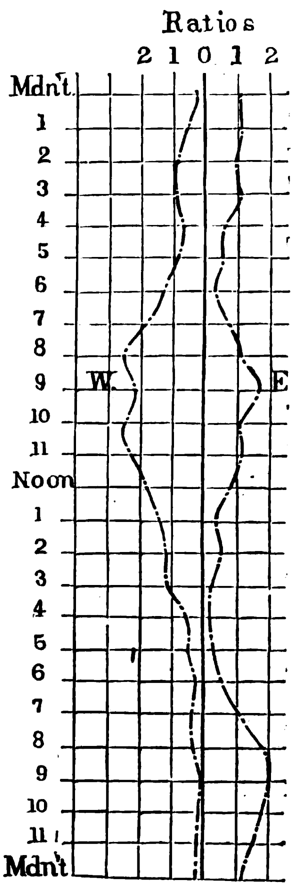
We notice the preponderance of easterly over westerly disturbances in every month except in March, which is no doubt occasioned by defective observations in the first year.

The disturbances, both westerly and easterly, reach a principal maximum in August and a secondary maximum in April; minima occur in June and December.

At Philadelphia, the corresponding months were October and April for maxima and June and February for minima.

Distribution of disturbances in the daily period.

Hours.	West.	East.	Total.	Ratios.		
				West.	East.	Total.
1 a. m....	14	43	57	.55	1.26	.95
2 a. m....	22	35	57	.86	1.03	.95
3 a. m....	23	41	64	.90	1.20	1.07
4 a. m....	18	21	39	.70	.62	.66
5 a. m....	21	21	42	.82	.62	.70
6 a. m....	32	12	44	1.25	.35	.74
7 a. m....	44	27	71	1.72	.79	1.19
8 a. m....	64	40	104	2.50	1.17	1.75
9 a. m....	53	60	113	2.07	1.76	1.90
10 a. m....	65	37	102	2.54	1.08	1.71
11 a. m....	54	40	94	2.11	1.17	1.58
Noon.....	46	30	76	1.79	.88	1.27
1 p. m....	33	15	48	1.29	.44	.81
2 p. m....	30	20	50	1.17	.59	.84
3 p. m....	28	9	37	1.10	.26	.62
4 p. m....	16	8	24	.62	.23	.40
5 p. m....	13	13	26	.51	.38	.43
6 p. m....	6	26	32	.24	.77	.54
7 p. m....	9	35	44	.35	1.03	.74
8 p. m....	7	63	70	.27	1.85	1.17
9 p. m....	2	68	70	.08	2.00	1.17
10 p. m....	5	63	68	.20	1.85	1.14
11 p. m....	4	51	55	.16	1.50	.92
Midnight.	5	40	45	.20	1.17	.75
Sum...	614	818	1432	24.00	24.00	24.00



The *westerly* disturbances show a single progression, the same as at Philadelphia and Toronto, with the maximum number between 8 and 10 a. m., and the minimum number at 9 p. m. The *easterly* disturbances, on the contrary, exhibit a double progression, nearly the same as at Philadelphia and Toronto, with the principal maximum at 9 p. m., the secondary maximum at 9 a. m., and with the principal minimum at 4 p. m. and the secondary minimum at 6 a. m. We thus have the *principal* maximum of easterly disturbances in direct *opposition* to the law of the westerly disturbances, whereas the *secondary* maximum of easterly disturbances is in *accord* with the law of the westerly disturbances, as shown in the accompanying diagram.

In general, the most disturbed time of the day is between 8 and 10 a. m., and the least disturbed time between 4 and 5 p. m.

With respect to *magnitude* of disturbances, the results are as follows:

The average magnitude of a disturbance from the six-year series between April, 1860, and April, 1866, is 3′.64.

The average magnitude of westerly disturbances equals 3′.49.

The average magnitude of easterly disturbances equals 3′.75.

The easterly disturbances are thus more numerous and of greater magnitude than the westerly disturbances. The largest disturbance recorded occurred August 3, 1865, at 4 a. m., when the magnet was deflected 21′.4 to the east of its normal position at that hour. The next largest deflection of 13′.8 was also to the east, and occurred on October 4, 1862, at 2 a. m. The largest *westerly* deflection was 11′.9, and occurred on March 1, 1862, at 1 a. m.; the next largest to the west was 11′.1.

Average magnitude of disturbances during successive years.

April to April.	Westerly.	Easterly.	Irrespective of direction.
	′	′	′
1860–61	3.6	3.7	3.6
1861–62	4.0	3.5	3.8
1862–63	3.5	3.8	3.6
1863–64	3.2	3.5	3.4
1864–65	3.4	3.7	3.5
1865–66	3.5	4.1	3.8

The easterly disturbances exceed the westerly ones in every year but one. The magnitudes do not indicate any dependence on the eleven-year cycle.

Average magnitude of disturbances in the yearly period.

Months.	Westerly.	Easterly.	Combined.	Months.	Westerly.	Easterly.	Combined.
	′	′	′		′	′	′
January	4.2	3.7	3.9	July	3.1	3.8	3.5
February	3.7	4.1	3.9	August	3.4	4.1	3.8
March	3.8	3.6	3.7	September	3.2	3.5	3.4
April	3.4	3.4	3.4	October	3.9	4.0	3.9
May	3.5	3.6	3.5	November	3.3	3.3	3.3
June	3.3	3.9	3.7	December	3.3	3.7	3.5

In every month but two, the easterly disturbances are larger than the westerly ones; no distinct monthly progression can be made out.

Average magnitude of disturbances in the daily period.

Hours.	Westerly.	Easterly.	Combined.	Hours.	Westerly.	Easterly.	Combined.
	′	′	′		′	′	′
1 a. m.	3.7	4.1	4.0	1 p. m.	3.3	3.2	3.3
2 a. m.	3.8	4.2	4.1	2 p. m.	3.4	3.2	3.3
3 a. m.	3.6	3.8	3.7	3 p. m.	3.5	3.3	3.4
4 a. m.	3.5	4.3	3.9	4 p. m.	4.0	3.5	3.8
5 a. m.	4.2	3.5	3.8	5 p. m.	4.0	3.5	3.7
6 a. m.	3.8	3.3	3.7	6 p. m.	3.9	3.5	3.6
7 a. m.	3.5	3.2	3.4	7 p. m.	3.4	4.0	3.9
8 a. m.	3.5	3.3	3.4	8 p. m.	3.4	4.2	4.1
9 a. m.	3.4	3.4	3.4	9 p. m.	4.1	4.2	4.2
10 a. m.	3.3	3.5	3.3	10 p. m.	3.9	4.0	4.0
11 a. m.	3.2	3.3	3.2	11 p. m.	4.6	3.8	3.8
Noon	3.1	3.1	3.1	Midnight	5.1	4.3	4.4

But for the rather small number of years of observations at Key West, the apparent law of change of magnitude of disturbances from hour to hour would come out quite distinctly, both for the western and eastern deflections; the smallest disturbances evidently occur about noon, and between 6 a. m. and 3 p. m. they are below their average value; during the night they are above the average.

Irrespective of direction, the disturbances increase regularly in size from noon, when they are a minimum (3′.1), to midnight, when they reach a maximum (4′.4); after this time, they decrease regularly till noon. We also notice the fact of disturbances of small magnitude (3′.3 to 3′.4) to

coincide with their greater frequency between 8 and 10 a. m., whereas they appear greater than the mean at the time (4 p. m.) when they are least frequent.

For comparison we have: minimum size of disturbances at Toronto, from a five-year hourly series commencing with 1844, at 1 p. m., at Philadelphia at 2 p. m., at Key West at 0 p. m.; also maximum size at Toronto about 9 p. m., at Philadelphia about 10 p. m., at Key West at 12 p. m.

While we possess a tolerably complete knowledge of the empirical laws of the various fluctuations in the magnetic declination for our Atlantic coast, we have as yet no material of investigation for our Pacific coast, and it is greatly to be desired that self-recording magnetic instruments may be established there at one or two stations, and maintained for at least six years.

The solar diurnal variation in the magnetic declination at Key West for the epoch 1863.3.

If we subtract each hourly mean of the preceding table of monthly normals from its respective monthly mean, we obtain the following table of the solar diurnal variation, expressed in minutes of arc, a + sign indicating a deflection of the north end of the needle to the westward, a − sign a deflection to the eastward.

The tabular values corresponding to six years of observation, and situated nearly between a maximum and minimum of the so-called sun-spot period of eleven years, may be supposed free of any effect of that period.

For comparison, I have added the Philadelphia table of the solar diurnal variation,* derived from five years of observations, and computed for the (exact) local hours; this table refers to the mean epoch 1842–43, which approaches to the minimum of the sun-spot period.

Solar diurnal variation of the magnetic declination at Key West, between April, 1860, *and April,* 1866.

Monthly means from hourly observations during six years.

Months.	1*h*.	2*h*.	3*h*.	4*h*.	5*h*.	6*h*.	7*h*.	8*h*.	9*h*.	10*h*.	11*h*.	Noon.
	′	′	′	′	′	′	′	′	′	′	′	′
January	+0.25	+0.38	+0.40	+0.31	+0.26	+0.06	−0.05	−1.14	−2.45	−2.75	−1.39	+0.43
February	+0.09	+0.17	+0.12	+0.05	−0.03	−0.08	−0.31	−1.11	−1.95	−2.03	−1.25	+0.12
March	0.00	+0.02	−0.10	−0.23	−0.53	−0.80	−1.88	−2.40	−2.18	−1.38	−0.13	+1.08
April	−0.25	−0.30	−0.51	−0.65	−0.75	−1.51	−2.81	−3.06	−2.21	−1.10	+0.45	+1.62
May	−0.27	−0.34	−0.39	−0.55	−0.89	−2.02	−3.44	−3.40	−2.14	−0.42	+1.15	+2.13
June	−0.06	−0.11	−0.22	−0.49	−1.04	−2.19	−3.49	−3.61	−2.42	−0.91	+0.86	+2.08
July	−0.05	−0.08	−0.13	−0.30	−0.78	−2.30	−3.62	−3.57	−2.47	−0.73	+0.85	+1.93
August	−0.12	−0.11	−0.09	−0.36	−0.81	−2.31	−4.54	−4.41	−2.77	−0.36	+1.56	+2.71
September	+0.08	−0.26	−0.46	−0.64	−0.74	−1.84	−3.64	−3.62	−2.34	−0.44	+1.48	+2.58
October	−0.02	−0.01	+0.06	−0.07	−0.11	−0.64	−1.86	−2.31	−1.76	−0.54	+0.69	+1.54
November	+0.36	+0.51	+0.41	+0.31	+0.13	+0.01	−0.49	−1.42	−1.72	−1.31	−0.26	+0.74
December	+0.39	+0.56	+0.59	+0.46	+0.36	+0.31	+0.16	−0.89	−1.96	−2.17	−1.44	−0.07

Months.	1*h*.	2*h*.	3*h*.	4*h*.	5*h*.	6*h*.	7*h*.	8*h*.	9*h*.	10*h*.	11*h*.	Midn't.
	′	′	′	′	′	′	′	′	′	′	′	′
January	+1.56	+1.90	+1.75	+1.11	+0.56	+0.30	−0.09	−0.30	−0.52	−0.40	−0.15	+0.03
February	+1.14	+1.52	+1.44	+1.10	+0.85	+0.54	+0.27	−0.06	−0.23	−0.21	−0.13	−0.08
March	+1.93	+2.15	+1.78	+1.05	+0.72	+0.55	+0.42	+0.13	−0.05	−0.07	−0.05	+0.02
April	+2.52	+2.87	+2.57	+1.90	+0.94	+0.55	+0.29	+0.22	+0.02	−0.13	−0.30	−0.30
May	+2.56	+2.61	+2.25	+1.45	+0.75	+0.45	+0.40	+0.31	+0.13	+0.05	−0.17	−0.22
June	+2.64	+2.81	+2.46	+1.73	+1.01	+0.49	+0.39	+0.29	+0.16	−0.06	−0.17	−0.09
July	+2.47	+2.63	+2.33	+1.62	+0.97	+0.53	+0.42	+0.33	+0.20	−0.02	−0.15	−0.12
August	+3.19	+3.18	+2.39	+1.48	+0.71	+0.39	+0.31	+0.21	+0.01	−0.11	−0.09	−0.06
September	+2.94	+2.54	+1.69	+0.83	+0.53	+0.46	+0.31	+0.16	+0.08	+0.11	+0.11	+0.08
October	+1.58	+1.28	+0.98	+0.76	+0.76	+0.49	+0.11	−0.19	−0.26	−0.22	−0.17	−0.17
November	+1.16	+1.08	+0.88	+0.61	+0.24	−0.01	−0.27	−0.42	−0.39	−0.26	−0.12	+0.13
December	+0.93	+1.44	+1.43	+1.04	+0.46	+0.06	−0.22	−0.46	−0.52	−0.34	−0.11	+0.08

* Coast Survey Report for 1860, pp. 306–307.

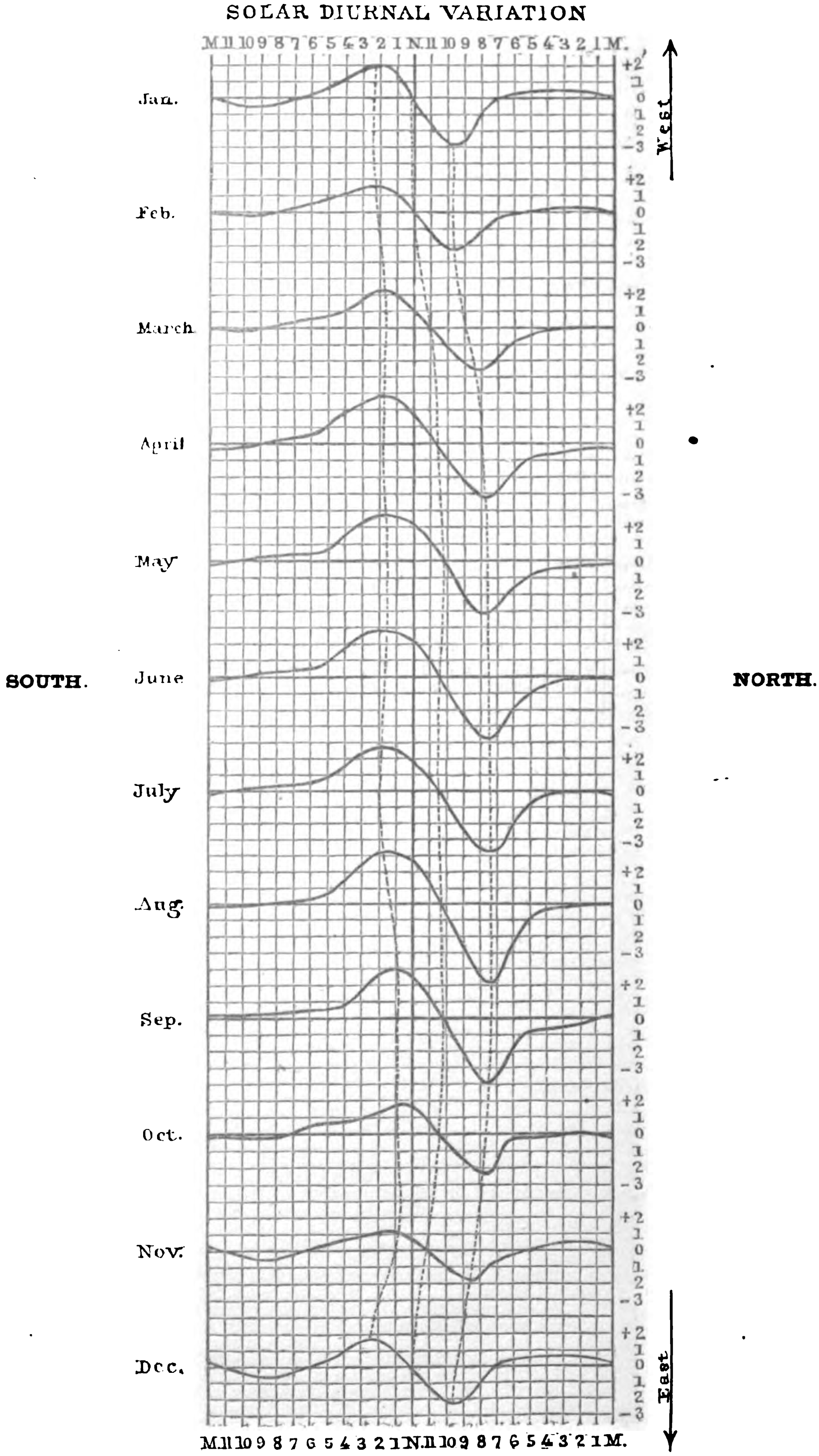
Solar diurnal variation of the magnetic declination at Philadelphia for epoch 1842.5.

Computed monthly means from bi-hourly observations between June, 1840, and September, 1843, inclusive, and hourly observations between October, 1843, and June, 1845, inclusive.

Months.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	Noon.
	′	′	′	′	′	′	′	′	′	′	′	′
January	−0.24	−0.30	−0.48	−0.48	−0.38	−0.55	−1.24	−2.12	−2.45	−1.59	+0.26	+2.26
February	−0.09	−0.14	−0.32	−0.49	−0.71	−1.18	−1.90	−2.52	−2.49	−1.49	+0.24	+1.96
March	−0.32	−0.55	−0.71	−0.81	−1.09	−1.84	−2.93	−3.67	−3.40	−1.81	+0.55	+2.71
April	−1.14	−1.34	−1.44	−1.54	−1.88	−2.64	−3.55	−4.02	−3.42	−1.54	+1.11	+3.60
May	−0.59	−0.50	−0.59	−1.18	−2.32	−3.75	−4.74	−4.66	−3.24	−0.81	+1.93	+4.06
June	−0.28	−0.41	−0.69	−1.32	−2.45	−3.87	−5.02	−5.13	−3.80	−1.23	+1.69	+3.99
July	−0.82	−0.67	−0.72	−1.34	−2.62	−4.22	−5.42	−5.45	−4.04	−1.47	+1.47	+3.90
August	−0.33	−0.21	−0.59	−1.60	−3.09	−4.68	−5.71	−5.48	−3.67	−0.58	+2.87	+5.44
September	−0.72	−0.90	−1.06	−1.42	−2.23	−3.51	−4.55	−4.50	−2.84	+0.11	+3.18	+5.18
October	−0.53	−0.30	−0.20	−0.16	−0.45	−1.33	−1.72	−2.18	−1.92	−0.79	+0.77	+2.60
November	−0.21	−0.32	−0.44	−0.56	−0.75	−1.18	−1.68	−1.91	−1.50	−0.37	+1.11	+2.31
December	+0.01	−0.02	−0.34	−0.60	−0.67	−0.73	−1.00	−1.44	−1.64	−1.09	+0.26	+1.86

Months.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	Midn't.
	′	′	′	′	′	′	′	′	′	′	′	′
January	+3.40	+3.34	+2.46	+1.52	+0.92	+0.57	+0.08	−0.64	−1.29	−1.45	−1.08	−0.52
February	+2.97	+3.02	+2.42	+1.71	+1.17	+0.76	+0.26	−0.36	−0.85	−0.97	−0.70	−0.30
March	+3.86	+3.85	+3.17	+2.33	+1.65	+1.02	+0.35	−0.31	−0.70	−0.67	−0.43	−0.25
April	+5.06	+5.18	+4.28	+2.98	+1.76	+0.88	+0.27	−0.14	−0.38	−0.54	−0.67	−0.88
May	+5.07	+4.88	+3.85	+2.48	+1.22	+0.39	−0.02	−0.12	−0.14	−0.21	−0.43	−0.58
June	+5.00	+4.79	+3.79	+2.60	+1.59	+0.87	+0.38	+0.07	−0.10	−0.13	−0.15	−0.19
July	+5.26	+5.37	+4.54	+3.28	+2.04	+1.16	+0.66	+0.39	+0.18	−0.15	−0.53	−0.80
August	+6.35	+5.55	+3.75	+1.98	+0.87	+0.50	+0.45	+0.26	−0.13	−0.56	−0.77	−0.62
September	+5.54	+4.48	+2.99	+1.68	+0.85	+0.33	−0.11	−0.44	−0.56	−0.55	−0.44	−0.52
October	+3.17	+3.00	+2.20	+1.08	+0.25	−0.39	−0.36	−0.39	−0.52	−0.69	−0.69	−0.44
November	+2.81	+2.58	+1.90	+1.18	+0.57	+0.06	−0.40	−0.59	−0.92	−0.77	−0.49	−0.23
December	+2.95	+3.04	+2.32	+1.34	+0.57	+0.11	−0.28	−0.78	−1.22	−1.33	−0.96	−0.36

Solar diurnal variation of the magnetic declination at Key West, Fla., for epoch 1863.3, and for every month, from hourly observations continued for six years.



The tabular results of the daily fluctuation in each month are exhibited graphically on the accompanying diagram, and it would appear from the great regularity of the successive hourly values that the labor of throwing them into an analytical expression can be dispensed with. The diagram is so arranged with respect to the *north end* of the magnet that the easterly motion is toward the right, westerly toward the left, the time-scale running, from up, down, commencing and ending at midnight. The following tabular results, which exhibit the characteristic features of the daily variation, are derived from a graphical process.

It will be noticed that, during the time when the sun is north of the equator, the curves present a certain similarity, different from that presented during the time when the sun is south of the equator. The first half year, including summer, comprises the months April to September inclusive; the second half, including winter, the months October to March inclusive.

Characteristic features of the daily variation.

Month or season.	Epoch of eastern elongation (morning).		Epoch of western elongation (afternoon).		Duration of westerly motion.	Daily range.	Mean declination reached, with motion to—			
	Time.	Deflection.	Time.	Deflection.			Westward, a. m.	Eastward, p. m.	Westward, p. m.	Eastward, a. m.
	h. m.	′	*h. m.*	′	*h. m.*	′	*h. m.*	*h. m.*	*h. m.*	*h. m.*
January	9 40	−3.0	2 20	+2.0	4 40	5.0	11 46	6 46	11 50	6 33
February	9 30	−2.2	2 10	+1.6	4 40	3.8	11 55	7 49	12 28	4 38
March	8 10	−2.5	1 40	+2.2	5 30	4.7	11 07	8 43	11 43	2 10
April	8 00	−3.1	2 00	+2.9	6 00	6.0	10 43	9 08	....	....
May	7 30	−3.7	1 30	+2.7	6 00	6.4	10 16	10 14	....	....
June	7 30	−3.9	1 40	+2.9	6 10	6.8	10 31	9 44	....	....
July	7 30	−3.8	2 00	+2.6	6 30	6.4	10 28	9 55	....	....
August	7 20	−4.9	1 40	+3.2	6 20	8.1	10 11	9 05	....	....
September	7 30	−3.8	0 40	+3.0	5 10	6.8	10 14	....	....	....
October	8 00	−2.3	1 10	+1.6	5 10	3.9	10 26	7 22	14 09	3 28
November	9 00	−1.7	1 00	+1.2	4 00	2.9	11 16	5 58	11 29	6 01
December	9 40	−2.2	2 30	+1.5	4 50	3.7	12 04	6 13	11 35	7 09
Sun north of equator (summer)	7 33	−3.9	1 35	+2.9	6 02	6.8	10 24	9 47	....	....
Sun south of equator (winter)	9 00	−2.3	1 48	+1.7	4 48	4.0	11 26	7 08	12 12	5 00
Yearly average	8 17	−3.1	1 42	+2.3	5 25	5.4	10 55	8 28	....	....

The preceding table, in connection with the diagram, completely defines the law of the daily variation. The cross-lines of dashes connect the times of eastern elongation, of western elongation, and of the intermediate normal position respectively, for successive months. The close conformity of the daily variation at Key West and at Philadelphia will be noticed; the secondary motion during the night, with a range of about half a minute of arc, is only perceptible during the winter months.

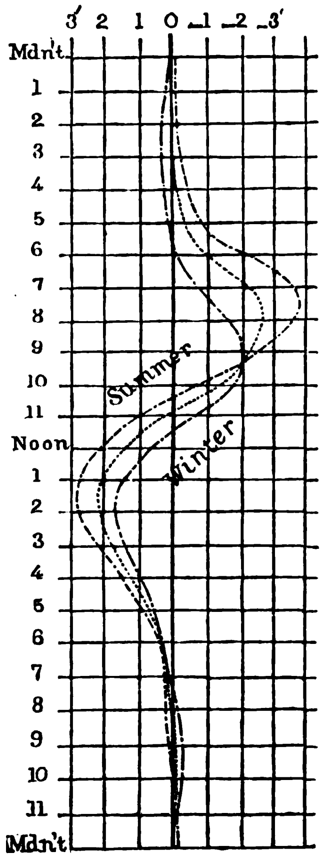
When the table is to be used for reducing any observed value of the declination to the mean of the day, the sign of the quantity must be reversed in order to serve as a correction.* The same remark applies to the Philadelphia table.

*At Key West, as well as at Philadelphia, the mean of the morning eastern elongation and of the afternoon western elongation will always represent the daily mean within less than 0′.6.

The greatest development of the daily variation occurs in August and the least in November, a feature common to Key West and Philadelphia. The *annual* variation in the diurnal motion of the magnet is best exhibited, for every hour, by the mean values for summer and winter.

Season.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	Noon.
	′	′	′	′	′	′	′	′	′	′	′	′
April to September inclusive	−0.11	−0.20	−0.30	−0.50	−0.83	−2.03	−3.59	−3.61	−2.39	−0.66	+1.06	+2.17
October to March inclusive	+0.18	+0.27	+0.25	+0.14	+0.01	−0.19	−0.74	−1.55	−2.00	−1.70	−0.63	+0.64
Year	+0.03	+0.04	−0.03	−0.18	−0.41	−1.11	−2.17	−2.58	−2.19	−1.18	+0.21	+1.40
Season.	**1h.**	**2h.**	**3h.**	**4h.**	**5h.**	**6h.**	**7h.**	**8h.**	**9h.**	**10h.**	**11h.**	**Midn't.**
	′	′	′	′	′	′	′	′	′	′	′	′
April to September inclusive	+2.72	+2.77	+2.28	+1.50	+0.82	+0.48	+0.35	+0.25	+0.10	−0.03	−0.13	−0.12
October to March inclusive	+1.38	+1.56	+1.38	+0.94	+0.60	+0.32	+0.04	−0.22	−0.33	−0.25	−0.12	0.00
Year	+2.05	+2.17	+1.83	+1.22	+0.71	+0.40	+0.20	+0.01	−0.11	−0.14	−0.12	−0.06

These results are also shown in the following diagram; the greater variability, both in time and amount, of the eastern (morning) elongation as compared with the western (afternoon) elongation is quite conspicuous.



Eleven-year inequality in the solar diurnal variation.

For the investigation of the so-called eleven-year period in the daily fluctuation, the normal hourly readings have been arranged according to years, each year beginning with April. The mean values are as follows:

Mean annual normals of hourly readings of the declinometer for six years, from April, 1860, *to March,* 1866, *inclusive, at Key West.*

Year.	1*h*.	2*h*.	3*h*.	4*h*.	5*h*.	6*h*.	7*h*.	8*h*.	9*h*.	10*h*.	11*h*.	Noon.
1860–61	65. 31	65. 34	65. 42	65. 64	65. 88	66. 69	67. 97	68. 52	68. 05	66. 63	64. 87	63. 37
1861–62	61. 72	61. 75	61. 71	61. 91	62. 16	62. 83	64. 08	64. 65	64. 35	63. 32	61. 69	60. 30
1862–63	58. 45	58. 43	58. 56	58. 67	58. 84	59. 70	60. 73	61. 22	60. 99	59. 88	58. 27	57. 03
1863–64	55. 12	55. 07	55. 11	55. 31	55. 63	56. 26	57. 22	57. 65	57. 32	56. 64	55. 56	54. 42
1864–65	52. 59	52. 58	52. 70	52. 80	52. 98	53. 62	54. 52	54. 67	54. 06	53. 02	51. 88	50. 98
1865–66	49. 99	49. 98	50. 06	50. 13	50. 35	50. 96	51. 86	52. 15	51. 80	50. 96	49. 82	48. 82

Year.	1*h*.	2*h*.	3*h*.	4*h*.	5*h*.	6*h*.	7*h*.	8*h*.	9*h*.	10*h*.	11*h*.	Midn't.	Mean.
1860–61	62. 52	62. 33	62. 92	63. 74	64. 32	64. 58	64. 72	64. 97	65. 23	65. 31	65. 37	65. 37	65. 21
1861–62	59. 35	59. 13	59. 45	60. 16	60. 80	61. 11	61. 29	61. 50	61. 62	61. 69	61. 77	61. 77	61. 67
1862–63	56. 26	56. 17	56. 53	57. 21	57. 67	58. 12	58. 32	58. 52	58. 65	58. 70	58. 68	58. 57	58. 51
1863–64	53. 79	53. 58	53. 72	54. 22	54. 71	54. 99	55. 20	55. 36	55. 43	55. 43	55. 47	55. 32	55. 36
1864–65	50. 80	50. 87	51. 20	51. 61	52. 08	52. 34	52. 68	52. 75	52. 85	52. 87	52. 74	52. 69	52. 58
1865–66	48. 34	48. 30	48. 58	49. 10	49. 56	49. 83	50. 02	50. 17	50. 28	50. 22	50. 12	50. 03	50. 06

Mean annual normal deflections at each hour.

[A + sign indicates westerly deflection; a − sign indicates easterly deflection.]

	Year.	1*h*.	2*h*.	3*h*.	4*h*.	5*h*.	6*h*.	7*h*.	8*h*.	9*h*.	10*h*.	11*h*.	Noon.
		′	′	′	′	′	′	′	′	′	′	′	′
I	1860–61	− 0. 10	− 0. 13	− 0. 21	− 0. 43	− 0. 67	− 1. 48	− 2. 76	− 3. 31	− 2. 84	− 1. 42	+ 0. 34	+ 1. 84
II	1861–62	− 0. 05	− 0. 08	− 0. 04	− 0. 24	− 0. 49	− 1. 16	− 2. 41	− 2. 98	− 2. 68	− 1. 65	− 0. 02	+ 1. 37
III	1862–63	+ 0. 06	+ 0. 08	− 0. 05	− 0. 16	− 0. 33	− 1. 19	− 2. 22	− 2. 71	− 2. 48	− 1. 37	+ 0. 24	+ 1. 48
IV	1863–64	+ 0. 24	+ 0. 29	+ 0. 25	+ 0. 05	− 0. 27	− 0. 90	− 1. 86	− 2. 29	− 1. 96	− 1. 28	− 0. 20	+ 0. 94
V	1864–65	− 0. 01	0. 00	− 0. 12	− 0. 22	− 0. 40	− 1. 04	− 1. 94	− 2. 09	− 1. 48	− 0. 44	+ 0. 70	+ 1. 60
VI	1865–66	+ 0. 07	+ 0. 08	0. 00	− 0. 07	− 0. 29	− 0. 90	− 1. 80	− 2. 09	− 1. 74	− 0. 90	+ 0. 24	+ 1. 24

	Year.	1*h*.	2*h*.	3*h*.	4*h*.	5*h*.	6*h*.	7*h*.	8*h*.	9*h*.	10*h*.	11*h*.	Midn't.	
		′	′	′	′	′	′	′	′	′	′	′	′	
I	1860–61	+2. 69	+2. 88	+2. 2[illegible]	+1. 47	+0. 89	+0. 63	+0. 49	+0. 24	−0. 02	−0. 10	−0. 16	−0. 16	Max.
II	1861–62	+2. 32	+2. 54	+2. 22	+1. 51	+0. 87	+0. 56	+0. 38	+0. 17	+0. 05	−0. 02	−0. 10	−0. 10	
III	1862–63	+2. 25	+2. 34	+1. 98	+1. 30	+0. 84	+0. 39	+0. 19	−0. 01	−0. 14	−0. 19	−0. 17	−0. 06	
IV	1863–64	+1. 57	+1. 78	+1. 64	+1. 14	+0. 65	+0. 37	+0. 16	0. 00	−0. 07	−0. 07	−0. 11	+0. 04	
V	1864–65	+1. 78	+1. 71	+1. 38	+0. 97	+0. 50	+0. 24	−0. 10	−0. 17	−0. 27	−0. 29	−0. 16	−0. 11	
VI	1865–66	+1. 72	+1. 76	+1. 48	+0. 96	+0. 50	+0. 23	+0. 04	−0. 11	−0. 22	−0. 16	−0. 06	+0. 03	Min.

The evidence of a connection of some kind between the amplitude of the daily variation and the spotted area of the sun is quite strong. If we commence with the year of maximum (nearly), spots marked I in the table, and end with the year of minimum (nearly), spots marked VI, we shall find a regular diminution in the *hourly values*. Thus, for 7^h a. m., the eastern deflection 2′.76 changes systematically into 1′.80; for 8^h a. m., 3′.31 changes to 2′.09; also the western deflection at 1^h p. m. changes from 2′.69 to 1′.72; and at 2 p. m., from 2′.88 to 1′.76. This diminution of the

amplitude, with the diminution of the sun's energy for the production of spots, is further exhibited in the following table of observed daily ranges on the yearly average.

	Observed magnetic amplitude.
	′
I (near maximum sun-spots)..	6.4
II..............................	5.6
III..............................	5.2
IV..............................	4.2
V..............................	4.0
VI (near minimum sun-spots) ..	3.9

The relative numbers expressive of the spot activity, according to Dr. R. Wolf, are as follows:

Year,	1860	1861	1862	1863	1864	1865	1866	1867
Rel. No.*	98.6 (max.)	77.4	59.4	44.2	47.1	32.5	17.5	8.0 (min.)

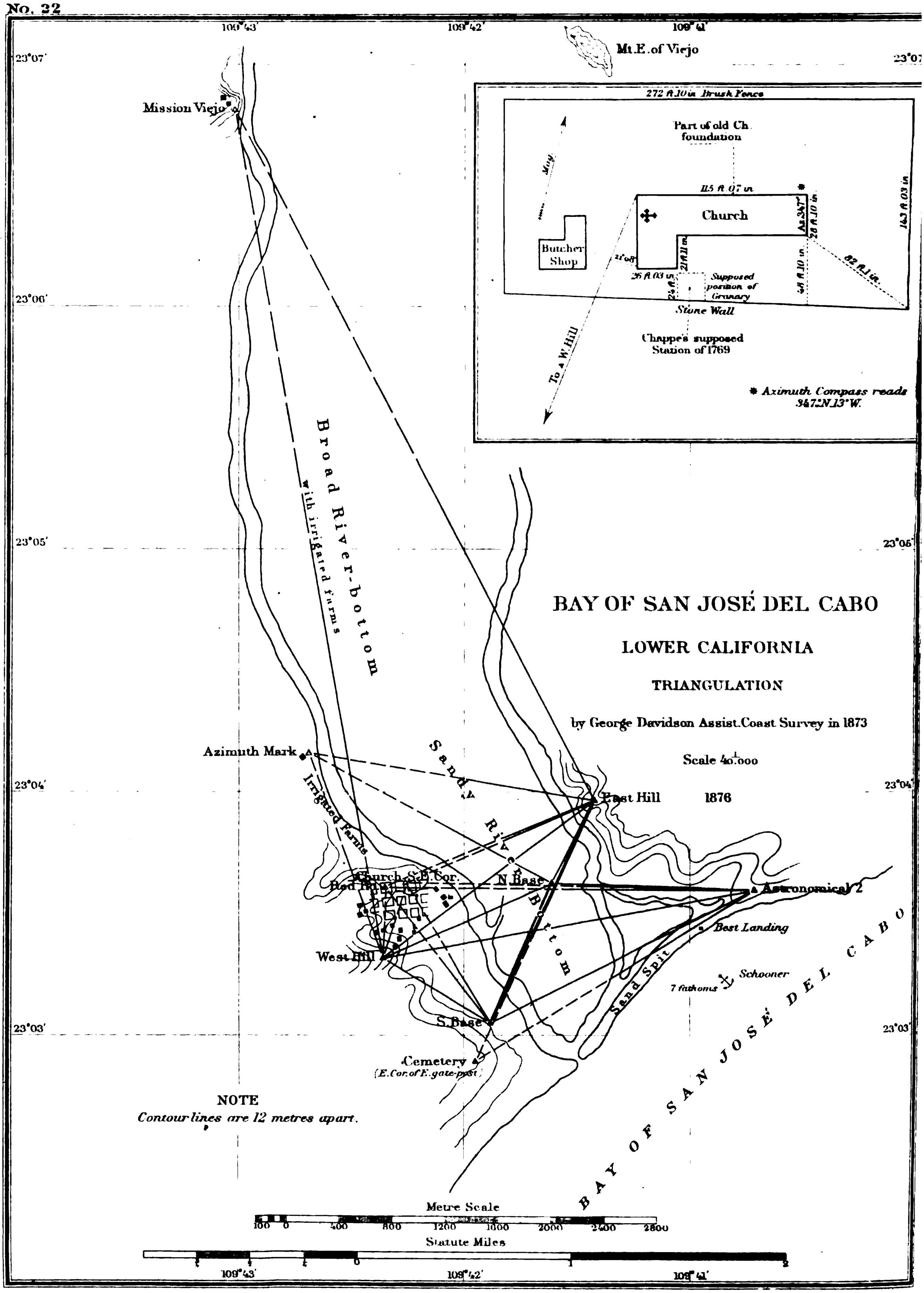
If the Key West declinations had been observed quite up to the two extremes, the daily amplitude would probably be found included between 6′.9 and 3′.8, the average amplitude being 5′.4.

It will be necessary, in using the table of hourly positions for the purpose of reducing observed declination at any one hour to the *mean* position of the day, to pay attention to the relation the year bears to the eleven-year cycle: thus, for a year of maximum sun-spots, the tabular numbers require to be multiplied by 1.3; for a year of minimum sun-spots, they require to be multiplied by 0.77 nearly; proportioned multipliers being needed for intermediate years.

The discussion of the *differential* observations of the horizontal and vertical forces may be given on a future occasion; also the investigation of the lunar effect on the declination, and a supposed effect on the same depending on the solar rotation.

* Astronomische Nachrichten, No. 1762.

No. 32



BAY OF SAN JOSÉ DEL CABO
LOWER CALIFORNIA
TRIANGULATION
by George Davidson Assist. Coast Survey in 1873
Scale 1/40,000
1876
Mt. E. of Viejo
Mission Viejo
Broad River-bottom
with irrigated farms
Sandy River Bottom
Azimuth Mark
Irrigated Farms
East Hill
Church S.E. Cor.
Red Hill
N. Base
Astronomical 2
Best Landing
West Hill
Sand Spit
7 fathoms
Schooner
S. Base
Cemetery
(E. Cor. of E. gate-post)
BAY OF SAN JOSÉ DEL CABO
NOTE
Contour lines are 12 metres apart.
Metre Scale
Statute Miles
272 ft. 10 in. Brush Fence
Part of old Ch. foundation
Church
Butcher Shop
Supposed position of Granary
Stone Wall
Chappe's supposed Station of 1769
To W. Hill
Azimuth Compass reads 347°N. 13° W.

APPENDIX No. 10.

TRANSIT OF VENUS, 1769.

RESULTS OF OBSERVATIONS FOR DETERMINING POSITIONS OCCUPIED IN LOWER CALIFORNIA AND AT PHILADELPHIA, REPORTED BY CHARLES A. SCHOTT, ASSISTANT, IN CHARGE OF THE COMPUTING DIVISION, COAST SURVEY OFFICE.

OCTOBER 7, 1874.

A trustworthy determination of the position occupied at San José del Cabo, Lower California, by Chappe d'Auteroche, when observing the transit of Venus in June 1769, has long remained a desideratum. It is believed that Chappe's observations are valuable; but they could not be fully utilized for want of a reliable longitude.* This information has at last been supplied by the Coast Survey, on the occasion of a reconnaissance of the coast of Lower California, in January, February, and March, 1873, by Commander P. C. Johnson, U. S. N., Assistant Coast Survey, in the steamer Hassler.

The duty of making the astronomical observations was assigned by the Superintendent, Prof. Benjamin Peirce, to G. Davidson, Assistant Coast Survey, aided by Wm. Eimbeck, subassistant.

For determining the longitudes, four sidereal and twenty mean-time chronometers were transported from San Diego, Cal., to Cerros Island, thence to San José, and returned to the same stations, which enabled the computer to introduce traveling rates for the differences of longitude.

Resulting differences of longitudes.

Designation of chronometer.	San Diego and Cerros Island.	Cerros Island and San José.	Designation of chronometer.	San Diego and Cerros Island.	Cerros Island and San José.
	m. s.	*m. s.*		*m. s.*	*m. s.*
A	−7 54.1	−22 03.2	10	−7 55.7	−22 04.6
B	49.3	03.4	11	54.9	03.7
C	50.9	03.3	12	56.0	01.6
D [excluded]	[41.8]	03.6	13	51.9	02.2
1 [excluded]	[47.8]	[21 55.3]	14	50.6	01.3
2	51.3	22 03.5	15	53.6	02.4
3	54.1	04.7	16	53.1	01.7
4	53.0	03.1	17 [excluded]	[59.0]	05.7
5	49.7	21 59.2	18	52.9	01.9
6	53.9	22 03.6	19	48.4	04.1
7	53.2	03.7	20	56.4	04.8
8	51.5	04.0	Mean	−7 52.52	−22 03.31
9	48.5	06.8		± 0.35	± 0.22

The astronomical station at San Diego is connected directly by wire and cable with Greenwich; its longitude, determined telegraphically, is $7^h\ 48^m\ 38^s.69 \pm 0^s.08$ W. of Greenwich. Adding the sum of the above results, we find, for the longitude of the astronomical station at San José del Cabo, $7^h\ 18^m\ 42^s.86 \pm 0^s.42$.

* See Dr. C. R. Powalky's dissertation "De transitu stellæ Veneris ante discum solis anno 1769, etc.", Kiel, 1864. Dr. Powalky made use of the "true" internal contacts, and introduced improved longitudes of positions. Those for stations within the United States were furnished him by the Superintendent of the Survey, the late Prof. A. D. Bache. With consideration of the weight of the observations at Jan José, he finds for the solar parallax 8''.86. Mr. E. J. Stone, Astronomer Royal at the Cape of Good Hope, afterward (Astronomical Society's Notices, 1868, vol. xxviii, p. 255) deduced the solar parallax $8''.91 \pm 0''.01$. He made use of the observed durations at San José, and introduced implicitly in his equations of condition the effect of both the apparent and true internal contacts.

The latitude of the same station was determined by means of a meridian telescope (a combined transit and zenith telescope); but, owing to an accident, the delicate level was broken during a storm at a preceding station, and, of necessity, the common level attached to the finder was substituted in the micrometric measures of north and south stars. The result obtained for latitude was $23^\circ\ 03'\ 35''.40 \pm 0''.47$.

A local triangulation was executed by Assistant Davidson, connecting this station with that identified by him as Chappe's observing position. A base was measured in the river-bottom, also an astronomical azimuth on the hill south of San José. These operations gave the following reductions:

Chappe's station north of astronomical station of 1873, $\Delta\ \varphi = +\ 1''.88$

Chappe's station west of astronomical station of 1873, $\Delta\ \lambda = +\ 1'\ 32''.01$

Hence, supposed position of Chappe's station of 1769,

$$\varphi = +\ 23^\circ\ 03'\ 37''.28 \pm 0''.47 \quad \Big| \quad \lambda = 109^\circ\ 42'\ 14''.91 \text{ W. of Greenwich.} \quad = 7^h\ 18^m\ 48^s.99 \pm 0^s.42.$$

The following remarks respecting the recovery of Chappe's station by Assistant Davidson are copied from his record-book:

"In 1871, I obtained a copy of Cassini's report of d'Auteroche's work, and from it gleaned the following particulars:

"EXTRACT.—'May 20, 1769.—I made haste to establish myself at San José, and to prepare for my preliminary observations. Myself and all my party took up their abode in a large granary. I had half the roof taken off toward the south, and put up an awning that could be spread out or furled at pleasure. All my instruments were fixed just as they were to stand to observe the transit of Venus. The weather favored me to my utmost wish. I had full time to make accurate and repeated observations for the setting of my clock. At last came the 3d of June, and I had an opportunity of making a most complete observation. It was necessary to commence at once to construct three pedestals of masonry for the firm support of the quadrant of three feet, the transit instrument, and the equatorial movement.' . . . .

"He observed for latitude with the quadrant, and obtained, from several stars, latitude $23^\circ 03' 36''.5$; from several observations on the sun he obtained $23^\circ 03' 05''$, and the final latitude* adopted, 'established very exactly,' was $23^\circ\ 03'\ 20''$. For longitude, he observed emersion and immersion of Jupiter's satellites, and obtained San José west of Paris $7^h\ 28^m\ 53^s$;† by an eclipse of the moon, $7^h\ 29^m\ 40^s$. The mission of San José is situated about one league from the coast, upon a little river which empties into the Vermilion Sea."

Assistant Davidson further remarks: "I arrived at San José del Cabo March 11, 1873; endeavored to gather information of the position of old church and granary; found the present church a recent structure; went about four miles up the river to the mission Viejo, established in 1728 or 1730; learned from Don Ramon Lesenya Talamanta where he had discovered the wall of the church and granary at that place and established the mission Viejo . . . . ; but this was not Mr. Chappe's locality. That mission had been abandoned before that time, and was located at San José del Cabo. At San José, I could get no clue to the date of the changes, and found that there had even been a third move toward the beach near the cemetery. But, from the sifting of the evidence I could collect, and the latitude of the present church, I felt satisfied this was the locality. The present priest is an Indian. He knows nothing of dates, but showed me the foundations of the old church and the position where the granary was traditionally reported to have stood. Its relation to the church was close, and the position well adapted for Mr. Chappe's work. I could not see the foundations, but he showed me where they were before the present filling to the top of the wall was made. The relation of the granary is given to that of the present church in the plan following the record of observations in this volume; and I think that the station of Mr. Chappe may be safely assumed to be within a space of 20 feet square."

* It will be noticed that his latitude result from the stars agrees, within less than a second, with the value determined in 1873, thus proving the value adopted in Dr. Powalky's dissertation, and again in Nos. 1811 and 1812 of the Astronomische Nachrichten (August, 1870), viz, $23^\circ\ 05'\ 15''$, to be in error.

† In Dr. Powalky's dissertation, the assumed longitude is $7^h\ 27^m\ 57^s$ west of Paris (supposed on Lalande's authority); subtracting $9^m\ 21^s.06$ (Coast Survey determination of 1872), we find his assumed longitude to be $7^h\ 18^m\ 35^s.9$ west of Greenwich. Chappe's own longitude from Jupiter's satellites corresponds to $7^h\ 19^m\ 31^s.9$ west of Greenwich, the correct longitude being $7^h\ 18^m\ 49^s.0$.

The accompanying sketch of San José and vicinity is taken from Assistant Davidson's record, the results of his triangulation having been introduced. Chappe's observing station would appear to have been about 14 meters above the sea-level.

In connection with the above subject of geographical position of a station occupied in 1769, there are some other American stations for which positions had been given, and which, by the introduction of telegraphic longitudes, can now be improved. The exact position of Rittenhouse's station in Philadelphia has also been recovered, for a reference to which I am indebted to W. W. Cooper, Assistant Coast Survey. We find in Watson's Annals of Philadelphia, vol. 1, p. 402 (edition of 1857): "The Declaration of Independence was read publickly from the platform of the observatory before erected there by Rittenhouse to observe the transit of Venus. It was about 20 feet high and 12 to 15 feet square, at 50 to 60 feet south of the house (State-House) and 15 to 20 feet west of the main walk." Mr. Cooper further remarks that the above position of the platform is in accord with the recollection of his childhood, when he saw a similar stand in the place referred to.

We have accordingly Rittenhouse's position 0″.70 south and 0″.38 west of the trigonometrical station steeple State-House, or in latitude 39° 56′ 52″.4, and longitude 75° 09′ 03″.0, equal to $5^h\ 00^m$ $36^s.20$ west of Greenwich.

The longitudes communicated to Dr. Powalky by the late Superintendent Bache, as given in his dissertation and in No. 1811, Astronomische Nachrichten (1870), require to be increased $1^s.3$, by which quantity the telegraphic result had increased our western longitudes as previously adopted in the Survey.

APPENDIX No. 11.

ADDITIONAL GEOGRAPHICAL POSITIONS DETERMINED ASTRONOMICALLY BY THE COAST SURVEY ON AND NEAR THE WESTERN COAST.

1873.—*Positions in Lower California.*—The latitudes were determined by a meridian telescope (transit and zenith telescope combined), the longitudes by chronometer transportations from San Diego, Cal., the longitude of which was carefully determined by the telegraphic method in 1871.

Locality—astronomical station.	Latitude.			Longitude in arc.			Longitude in time.		
	°	′	″ ″	°	′	″ ″	h.	m.	s. s.
Cape San Lucas	22	53	06.76 ± 0.64	109	54	50.2 ± 6.4	7	19	39.35 ± 0.43
San José del Cabo	23	03	35.40 ± 0.47	109	40	42.9 ± 6.3	7	18	42.86 ± 0.42
Chappe's transit-of-Venus station of 1769 at San José del Cabo granary	23	03	37.28 ± 0.47	109	42	14.9 ± 6.3	7	18	48.99 ± 0.42
Magdalena Bay	24	38	22.83 ± 0.42	112	08	54.2 ± 6.6	7	28	35.61 ± 0.44
Pequeña Bay	26	14	33.01 ± 1.10	112	29	24.0 ± 6.3	7	29	57.60 ± 0.42
Abreojos Point	26	42	49.43 ± 0.66	113	35	03.9 ± 6.1	7	34	20.26 ± 0.41
Ascension Island	27	06	21.35 ± 0.82	114	18	13.5 ± 5.6	7	37	12.90 ± 0.37
Cerros Island	28	03	51.96 ± 0.46	115	11	32.5 ± 5.4	7	40	46.17 ± 0.36
Lagoon Head	28	14	26.32 ± 0.60	114	06	21.2 ± 6.1	7	36	25.41 ± 0.41
La Playa Maria	28	56	06.72 ± 0.83	114	31	05.7 ± 6.4	7	38	04.38 ± 0.43
San Geronimo Island	29	47	20.27 ± 1.40	115	48	12.2 ± 6.3	7	43	12.81 ± 0.42
San Martin's Island	30	28	58.30 ± 0.93	116	66	45.5 ± 5.7	7	44	27.03 ± 0.38
Todos Santos Bay	31	43	09.65 ± 0.65	116	40	48.7 ± 3.7	7	46	43.25 ± 0.25
San Diego, Cal., station of 1871 *				117	09	40.3 ± 1.2	7	48	38.69 ± 0.08

1873.—*Longitude of Kalama, Washington Territory,* determined by means of the telegraph from San Francisco.—The latitude of Kalama astronomical station is 46° 00′ 17″.79 ± 0″.10.

	h. m. s. s.
Difference of longitude, San Francisco (Washington Square observatory) and Kalama astronomical station	0 01 43.88 ± 0.026
San Francisco (Washington Square) west of Greenwich	8 09 38.35 ± 0.08
Kalama astronomical station west of Greenwich	8 11 22.23 ± 0.084
	= 122° 50′ 33″.45 ± 1″.26

1871.—*Longitude of Seattle, Puget Sound, W. T.,* determined by means of the telegraph from San Francisco.—The latitude of Seattle astronomical station is 47° 35′ 54″.33.

	h. m. s. s.
Difference of longitude, San Francisco (Washington Square) and Seattle astronomical station	—0 00 18.42 ± 0.02
San Francisco (Washington Square) west of Greenwich	8 09 38.35 ± 0.08
Seattle astronomical station west of Greenwich	8 09 19.93 ± 0.08
	= 122° 19′ 58″.95 ± 1″.20

1872.—*Longitude of Verdi, Nev.,* determined by means of the telegraph from San Francisco.—The latitude of Verdi astronomical station is 39° 31′ 04″.70 ± 0″.07.

	h. m. s. s.
Difference of longitude, San Francisco (Washington Square observatory) and Verdi astronomical station	—0 09 47.33 ± 0.03
San Francisco (Washington Square) west of Greenwich *	8 09 38.35 ± 0.08
Verdi astronomical station west of Greenwich	7 59 51.02 ± 0.09
	= 119° 57′ 45″.3 ± 1″.3

* Former telegraphic determination increased by $0^s.03$ to include effect by third Atlantic cable, used in 1872.

APPENDIX No. 12.

REPORT ON AN INSPECTION OF THE TERMINAL POINTS OF THE PROPOSED CANALS THROUGH NICARAGUA AND THE ISTHMUS OF DARIEN, BY PROFESSOR H. MITCHELL, UNITED STATES COAST SURVEY.

GREYTOWN (SAN JUAN DEL NORTE).

The examination of the coast in the immediate neighborhood of Greytown and the outlets of the Lower San Juan River has satisfied me that a reconstruction of the harbor is practicable. This conclusion is based upon a particular conception of the causes which led to the destruction of the old port, and a conviction that these causes, still active, may be successfully resisted by artificial works. I quote the following from the Report of the Committee of the National Academy, made in 1866.—

History of Greytown Harbor.—"The earliest source of information that we feel warranted in using is the sketch to be found in Mr. Molina's work upon Costa Rica, which is based upon a survey by George Peacock in 1832, and has additions showing the progress of the sands of Isla Castilla down to 1848.

"In 1832, five fathoms of water could be carried from sea to a point within the present basin of Greytown Harbor, through an opening which measures one and three-fourths miles from Isla Castilla to the west shore. At that time, the avenue to the sea was *without* a *bar*, and the regular decline of the bottom along the seaward channel-way gave no indications of the action of scouring forces. There was *no depression* at the harbor's mouth and no *accumulations* beyond, that seemed in any way to be a dependency upon the existence of the basin or its outlets. The shallow ground lying along the coast outside of Isla Castilla, and projecting beyond to the westward, would seem, upon Mr. Molina's sketch, to be a concomitant or parallel to this island as well as an outwork of the advance. Subsequent surveys, however, dissolve this apparent connection and relation.

"The embouchure of the Lower San Juan River is found in this first survey at the head of the anchorage basin, and the deposits of that stream appear to be nearly two miles within the harbor's mouth.

"Between 1832 and 1834 a movement of the sands to the westward occurred, which extended the point of Isla Castilla about 456 feet per annum. This extension took the form of a hook. From 1834 to 1835 the point advanced 608 feet. Four years later, in 1839, it was found to have advanced 1,065 feet, or at the rate of 266 feet per annum. Between 1839 and 1840 it advanced about 400 feet. Between 1840 and 1848, a space of nearly eight years, it advanced 221 feet per year, and in the next succeeding ten months 913 feet were added, or the beach grew at the rate of nearly 1,100 feet per annum. The harbor as a protection to shipping had been improving up to the last date upon Mr. Molina's sketch, but its opening from the sea had become reduced to about 0.8 of a mile, a loss of over 50 per cent.

"In 1853, we find the mouth of the harbor, measured upon the same line as before, reduced to 0.52 of a mile, a reduction of 35 per cent. since 1848. In this period of four and a half years, the sand-spit made an average annual advance of 401 feet. The physical character of the harbor had thus far undergone no change; the same good depth of water could be carried in; the same gradual decline of the bottom to seaward was preserved, and no bar or shoal lay in front. The point of Isla Castilla called on this more recent map Punta Arenas, had been made across the floor of the sea by sands thrown in from above, not scoured from the bottom; it was built out like a mole, the material taking nearly its natural slope, and not suffering waste under the action of any currents from within. In this chart of 1853, an opening through the beach is found about at the extremity of the Castilla of 1832. As a physical feature it does not yet seem important.

"The survey of 1856 found the dry portion of Point Arenas advanced nearly due south from its position in 1853, and a gradual shoaling-off to the westward, reducing the harbor's mouth to 0.3 of a mile. At this time, the point was broad and hooked. The same depth of water could be carried in as formerly, and no bar was found outside.

"Between October, 1856, and January, 1859, two and a quarter years, Point Arenas advanced to the southwest 1,156 feet, or at the rate of about 514 per annum. Even as late as 1859, when the harbor's mouth was reduced to 0.13 of a mile, the only trace of any action from within was the retreat of the 18-feet line on the west shore.

"According to a note upon the British chart, the entrance was reduced to 300 feet in 1861; while, in January, 1865, Captain Jones, of Her Majesty's ship Shannon, reports that the entrance has a bar across it after a norther, though after a continuance of fine weather the scour of the river increases the depth to 8 or 10 feet. The passage on the opposite side has also reduced to 50 or 60 yards."

"Our final authority is the survey made under the direction of Captain P. C. F. West, who brought to the field the skill and accuracy of long experience in the Coast Survey, to which corps he now belongs.

"In this survey, made in February, 1865, the change in the physical character of the harbor, shadowed forth in the note that we quoted from the British chart, is confirmed. The anchorage has become a lagoon, with an uncertain *inlet.* Between Point Arenas and the opposite shore a depression of 20 feet is found, to reach which 17½ feet must be passed in the approach from the harbor and 8 feet in the approach from the sea. Here we have the *depression at the opening* and the *bar outside*, which are the characteristics of a true *inlet*, for which we have looked in vain upon the earlier charts.

"After the completion of the general survey, Captain West's party found, in May, that the opening at Greytown Harbor had closed, and that a breach had been made farther to the westward."

Causes of the decline and final destruction of the harbor.—The quotations which I have made from the report of the academy indicate somewhat the view entertained by the committee regarding the causes which formed and ultimately destroyed the harbor; but I may be permitted to restate the matter briefly from a review of other portions of the same report.

The harbor of Greytown was originally a re-entrant angle or cove, lying between the delta of the San Juan River and the adjacent coast to the northwestward. Near the head of this cove there entered an offset of the San Juan River (bearing the name of the parent stream originally, but recently, for distinction, called the *Lower* San Juan), which formed a subsidiary delta of its own within the cove.

This cove, opening to the northward, was in the course of time converted into a lagoon by a mole of sand driven across the mouth by the waves from the northeastward, which swept past the outer shore of the main delta. It became a harbor easy of entrance and perfect in shelter at the intermediate stage, when the mole had reached within a couple of miles of the main shore to the westward, at which time the channel-way from the basin to the sea was in no wise dependent upon the outflow of the Lower San Juan, nor upon the tides, but was simply an avenue, not yet encroached upon, whose bed was the original floor of the ocean. It was not until the mole had nearly crossed to the opposite shore that the river outflow and the tides began to act upon the bed and banks of the outlet, resisting the absolute closure of the basin.

Opposed to the view of the case stated above is another, quite different in character, which has been urged by nearly all the engineers who have visited Nicaragua, and is not to be ignored, because, if it is the correct view, it materially alters the question of the practicability of a restoration, or, at all events, modifies the plan of improvement. In stating this opposite theory of the case, I shall, as nearly as I can remember, repeat the words of Don Maximillian Sonnenstern, the accomplished engineer of Nicaragua.

"The sand-bar (Punta Arenas) which now separates the Greytown basin from the sea is a part of the delta of the Lower San Juan River, and is formed from material swept down this river in floods. In former times, the Lower San Juan received a much larger proportion of the waters of the parent stream, and was able to maintain a grand opening to the sea; but recently the main

river has chosen to send its waters to the sea by the Colorado, and in this way the Lower San Juan has been deprived of the power of pushing its *débris* into the sea, and thus maintaining a ship-channel through *Punta Arenas*."

I think I have stated the two theories fairly, and it only remains to add a few considerations which have confirmed me in the view held by the committee of the academy:

1st. Standing upon the outer beach of Punta Arenas, I have been witness to the movemen of the sand to the westward. The waves drive on *diagonally* (at an angle of 45°), carrying up the strand gravel, shells, &c., which, upon the recoil, are, for the most part, carried down again to the sea, but in a direction *normal* to the shore-line. In this way, by a zigzag movement, the sands, etc. travel slowly along the coast, and pile themselves up against the main shore to leeward. It is pre cisely the same movement that has formed Long Point at Provincetown and Sandy Hook at New York. The only difference is that at Provincetown or New York we have the mole in that earlier stage of its formation at which it acts as a breakwater and not a barrier.

In the interval between Captain West's survey of 1865 and that of Commander Lull's of 1872–73, there accumulated upon the western shore, *to leeward of the inlets through which the river-waters had been discharged*, over twenty-five acres of dry sands, in addition to that found by Captain West. A single line of levels over these sands, made by Mr. Menocal and myself, gave 6½ feet summit elevation over the site of the ship-channel of fifteen years ago.

2d. The sands, etc., composing Punta Arenas are like many other beaches, as far as regards the size of the grains, etc., both on the ocean and basin sides.* In other words, the mole is built of *selected material*, sifted out by the long-continued action of the sea—the work not of a few years, but of centuries perhaps. These selections have been made from a vast deposit of mud, of which they form an exceedingly small proportion.†

3d. The once grand entrance of Greytown could not have been maintained by the San Juan, even if it had been the only avenue of discharge from the main artery. One has only to divide the discharge (measured by any of the engineers) into the cross-sections of the ship-channel given upon the old charts, to discover how powerless the seaward flow must have been. From the best computation that I can make with the data at hand, I find that in 1832 the section of the entrance to Greytown was *seventy times* the area that we have now in the Lower San Juan at the head of the passes; *eighteen times* the section of the main river above the Colorado in dry seasons; and *seven times* the sections of the main river in "top-gallant floods".‡ Even as late as 1853, the section at the entrance to Greytown Harbor was five times as great as that of the main river.

The work of restoration.—Since the principal element in the scheme of reconstruction is the amount of resistance to be offered to these causes of obstruction which we have discussed above, it may be important, by the comparison of the two last surveys, to measure, as well as we can, how much work injurious to our purpose the natural forces are doing.

In the interval between Mr. West's survey of 1865 and Captain Lull's of 1872, the narrow strip of beach westward of the meridian of the Greytown Catholic church has been continually modified in the contest between the waves of the sea and the outflows from the basin. The waves driving from the northeast before the trade-winds have sought to crowd the sands directly along the shore to the southwestward, while the pent-up waters of the basin have repeatedly burst through the beach and forced the sands seaward at the successive points of attack. The result of this contest has been that this strip of beach has moved to the northwestward in the course which we may presume to be that of the resultant of the forces at work. This movement has enlarged the basin superficially, but at the expense of its depth. §

Aside from the sediments of the river, there seem to have been accumulations due to the forcing

* The grains are smaller than those of Long Island, but correspond pretty well with those of Cape Fear.

† Cross-sections run by Captain Huer and Lieutenant Miller gave the usual forms of profile for traveling-beaches.

‡ Mr. Barnes, a resident at the "Forks", pointed out the height of what he called the "*top-gallant floods*", of which we measured the elevation.

§ The two tracings from the original surveys of Captain West and Commander Lull (both executed under difficulties) are differently oriented, there being some difference probably in the compasses used; and their distances do not agree, so that, aside from the outward movement of the dry beach, there is a difference of areas, which is accidental, amounting to over seventy acres, Commander Lull's map being the larger.

in of material from outside with the flood-current and the waves. The shoaling amounts to an average of 2½ feet by comparison of the same areas.

Assuming that the water-front of the town has remained unchanged for the distance of a nautical mile westward of the Catholic church, I have been able to bring the maps of 1865 and 1872 together pretty well; and I have drawn a north and south line (magnetic) through a point 1,250 feet west of the church to define (for convenience) the eastern limit of the basin. In the interval between these two surveys, there has been a decided advance of the bank of mud at the mouth of the Lower San Juan. The comparison of the maps gives this about 40 acres; but it would be difficult for any two surveyors to agree in the areas of these banks, because their limits are not defined. These are "drowned lands", with almost imperceptible slopes toward the basin at many points, so that one cannot say just where the nominal shore-line should be placed. There is, however, no doubt of there having been a considerable advance, *and yet the cubical water-contents of the basin have declined only 2 per cent.*

The change in the area of dry sand is likewise no criterion for judging of the increase of the mole which has cut off the basin from the sea. One might suppose, from the correspondence of areas between the Punta Arenas of Captain West and that of English charts twenty years earlier, that the advance of the point had been made with material robbed from older parts of the beach; the strip of land seeming to have undergone an attenuation as it crept forward. A comparison of soundings outside, however, quickly dissipates this impression, and shows that a great movement and accumulation of sand has been going on along the bottom as far seaward as the four-fathom curve at least, and that the fluctuations of the dry summit are unimportant phenomena physically.

If we compare the space which, upon Captain West's map, lies between the inside shore-line of Punta Arenas (continued on its general trend) and the five-fathom curve outside, with the same actual space upon Commander Lull's map, we find the increase of dry beach about fifty-two acres, which, at its average height, about 3 feet, would represent only about a quarter of a million of cubic yards; but, taking the submerged volumes, we discover that Punta Arenas has received deposits (on its seaward side) to the amount of five and a third millions of cubic yards, being an average of 730,000 cubic yards per annum.*

As we might have expected, from the nature of the movement down the outside shore before the sea, the most rapid accumulations have taken place at the end of the beach, where, on reaching the mainland, the further progress of the material is arrested. Here, in a triangular space of one hundred and sixty-five acres, the dry land has increased from eleven acres in 1865, to thirty-seven and a half acres in 1872, and the water-volume diminished from three and a half millions, 1865, to one and a half millions, 1872.†

Our purpose in stating the accumulations in this triangular space separately is to give some measure of the rapidity with which the material is likely to advance toward the end of any jetty or groin which may be extended from the beach, with a view of arresting the progress of the sands which might tend to encumber an artificial opening through the beach. We shall refer to this matter again presently from another point of view, but must pause here to consider the relations of the river to the beach.

The material of Punta Arenas, like other beaches, is sand sifted by the sea. It is probably derived indirectly from the San Juan River, precisely as the sands which are encroaching upon the western pier of Port Säid are derived from the Nile; but we have no data for computing how long ago the river delivered to the ocean the enormous mass of mud from which these grains of sand have been so carefully selected. River-muds are usually over 90 per cent. sand, but mostly very fine sand as compared with that on outside beaches. In illustration, I will recall an incident connected with our physical survey of Mobile River and Bay made a dozen or more years ago. Along the shore of this bay, in Garrow's Bend, there is a little belt of white sand which I could not believe was the product of the dash of the waves against the bluff, because the latter was composed of a very fine yellow clay. General Totten, however, to whom I gave specimens of both materials, suc-

* The whole area of the space is seven hundred and forty-two acres. Want of numerous and coincident soundings makes this a rough computation. I make the total 5,379,110 cubic yards, and the interval of time seven and a third years.

† From 3,678,400 to 1,557,802, as computed from data insufficient for nice statement.

ceeded, by treating the clay with acids, and by laborious washing, in detecting a few grains of the very same sand which lay at the foot of the bluff; but the ratio of these to the bulk of material from which they had been selected was too small to be determined. At the mouths of rivers which are rapidly extending their deltas, one does not find the sand sifted out in recent deposits; but at some ancient mouth, long since closed to the discharge of river-floods, he may find a belt of beach-sand, having a very foreign aspect, but really sifted from the river-muds in the long course of time.

The Lower San Juan has so extended its delta as to merge its mud, of late years, with the sands of Punta Arenas (or Isla Costilla, as the eastern portion of the beach is called), but the ground over which it advances is much of it shallow, so that a small volume of sediments makes considerable area. We have not succeeded in making any satisfactory computation of the amount of *débris* brought down by this river, but it does not, I think, exceed a hundred thousand cubic yards per annum as measured in the Greytown basin.

The plan already proposed by Commander Lull for restoring the harbor comprises three important works, viz: the dredging away of a portion of Punta Arenas and its aproning of shallow ground; the construction of a jetty to windward of the new opening, so as to shelter the approach from the sea, and protect the channel from the wash of the waves; and the diversion of the waters now flowing through the Lower San Juan into the Colorado by obstructions at or near the Forks. The object of the last-named work is to prevent sediments from encumbering the Greytown basin, etc.

This plan, as far as regards the main points stated above, is not inconsistent with the view I have adopted relative to the causes of injury heretofore and the obvious means of resisting them in the future, and I purpose to discuss this plan, not to present any fundamental objections, but to see how it answers criticism from this different standpoint:

1st. A jetty designed to arrest the traveling sands of the coast most effectually should extend in a direction nearly normal to the shore, and yet have a tendency to turn the sea slightly shoreward, so as to prevent the sands from escaping by the *race* round the end of the pier. The jetty plotted upon the map sent to me answers these tests pretty well. A position has been chosen where a line at right angles to the general shore-line (which trends southwest in this neighborhood) is slightly inclined toward the direction of the sea, which, although created by the northeast trade-wind, is modified in the direction of its onset as it approaches the coast, so as to strike at a less angle than it would if driven directly before the wind.

2d. The jetty intended to shelter the approach to the interior basin should serve as a breakwater to vessels obliged to come to anchor outside when unable to come in by reason of darkness, or when waiting for a tow.

The jetty, as plotted, 3,000 feet long, will shelter nine ships under its lee, as the bottom now lies, and double this number if dredging is done within a reasonable distance of the beach and the entrance. These estimates are based upon the consideration that the wind is nearly constant, so that vessels may be expected to swing together over an octant of 500 feet radius, and that the least depth of water required will be 18 feet.

We were told at Greytown that vessels anchor at all seasons of the year on this coast, and escape injury, although they lie uncomfortably, even in ordinary weather, while the trade-winds prevail.

The sea of the Caribbean is often high, but it is very short from rear to front, so that a wave has no great volume, and under the shelter of a breakwater no considerable swell may be expected. Captain Selfridge informed me that he had found the water perfectly quiet in Porto Bello when the sea outside was running very high with the northeast trade-wind. This harbor is a good illustration, because it is scarcely two miles long, and opens divergently toward the sea. The exposure is, however, to the southward of west, so that the sea runs away from it. We shall have occasion to refer to this again when we come to speak of ports on the Pacific side of the isthmus.

It may be found necessary to extend the jetty at Greytown; to add a *kant* running westward from its extremity; but this could only be decided upon after ascertaining how fast the sands are disposed to creep out on the windward side, and how they may be inclined to deposit themselves beyond or within the end of the structure.

We may venture, not without misgivings, because of the inadequacy of our information, to make an estimate of the time that may elapse before the sands would accumulate as dry beach out to the end of the proposed jetty. We have already seen how rapidly the accumulations have taken place

against the west shore, and we know that we have to resist the movement of nearly three-quarters of a million of cubic yards per annum. It is an important question, *how far the reaction of the jetty may extend to the eastward*, because upon this reaction depends the form which the bank will take at Port Säid, which is situated on the flank of the delta of the Nile much in the same way that Greytown is placed relative to the main delta of the San Juan. The accumulations have taken place in long triangular banks with bold fore shores. Instead of piling up directly against the jetty, the shore, for perhaps a mile, has moved outward, each deposit against the mole having reacted and formed another deposit farther back. In this way, the advance toward the end of the structure has been very slow. In a very general way, perhaps, we can detect a similar reaction along the shore since Punta Arenas completed its advance westward; at all events, the outward movements, although irregular from point to point, are not in any respect confined to the immediate vicinity of the obstruction (the main shore). On the contrary, they happen to be less there than farther eastward, although the volume of accumulation is greater. Rejecting the shore-line, however, as being the least important contour, because the most liable to accidental movement, we shall descend to the four- and five-fathom curves and observe how they have advanced.

In the interval between the survey of Captain West and that of Commander Lull, seven and a quarter years, we find that the fore slope of the beach, between the four- and five-fathom lines, moved out, in the average, 100 feet per annum. At these depths, it is hardly likely that the washing-away of the beach in storms has had much effect; and, of course, one of the first steps taken (should improvement be decided upon) will be to secure this beach, so that we need not take these accidents into account.

It is a curious fact that in the first 3,000 feet from the west shore (measured along the present beach) the increase of dry land was just as great as it was for the next 7,000 feet eastward (26½ acres), while the accumulation above and below the water's surface was two and a quarter millions of cubic yards in the first distance, against three millions in the second.* So that while the dry land increased its area in the vicinity of the obstruction (the west shore) more than double as fast as at points beyond *its* influence, the accumulation in the neighborhood of the obstruction was only at about 67 per cent. higher rate. Now, supposing that the reaction of the obstruction continues along shore, we may finally conclude, from the foregoing argument, that a jetty built as proposed will cause an advance of the submerged contours at a rate not greater in the average than 167 feet per annum; and if the bank that is formed takes the successive shapes which repeated surveys gave at Port Säid, this rate will be reduced from year to year, because the base of the triangle of deposit will extend farther and farther eastward. There may be expected a rapid filling-up of the inner portion of the angle behind the jetty, especially where the water is now shallow.

As the filling proceeds, the contours will trend more nearly parallel with the crest-line of the wave, the reaction will extend farther along shore, and deeper water will be reached. Here are three substantial reasons for expecting a reduction in the rate of advance of the back side of the jetty. From comparisons of our recent maps with the old British charts, it appears that the waves are not *directly* active along the space between the five- and six-fathom curves. Opposite the original opening, we still find a five-fathom channel leading up a little way toward the beach, where no deposits have taken place. This channel has been narrowed down by encroaching banks; but there is still a considerable space left at the old depth.

The accumulation behind the jetty will probably take a steep fore shore, and in the time we have given above for this jetty to fulfill its office enough will be learned concerning the manner in which the sands are disposed to accumulate beyond the pier-head to enable the engineer perhaps to turn this very accumulation to account in securing greater shelter to the roadstead.

The Dutch have found on the coast of Holland, in using fascinage, that the traveling sand can be made to do service in giving permanence and strength to structures designed to resist the

* 2,249,342 and 3,129,798 cubic yards of filling, of which 2,120,598 and 3,004,794 represent water-displacements from Captain West's chart in territory still covered with water, is beyond the present shore-line.

I have no information concerning the jetty at Port Säid since 1868, the date of my visit, when I procured tracings of surveys of the successive shore-lines. I discussed the Port Säid Harbor in an article on the Suez Canal, which appeared in the North American Review for October, 1869.

action of the waves. In building the proposed jetty, which I understand to be an initiatory step, it would be well to use fascinage near the shore, because of its tendency to gather the sands and holding them, and because heavier materials would be likely to sink. Cribs would be likely to be eaten by the worms; but blocks of artificial stone made from the lime of the country and the sand of the beach would be durable, if we may judge from the firmness of similar material used for wells and indigo vats near Rivas.*

Obstructions of the Lower San Juan.—A comparison of the gaugings made by Childs, West, and Lull shows that the Lower San Juan is losing its capacity of discharge, and that we may expect, at no distant day, to find this stream relinquishing its office as an outlet from the main river, at least in the dry season. Commander Lull's project provides for hastening the decline of this stream, by placing obstructions in the shallow sections of the river near the *Forks*, so as to induce the main river to send all its *débris* to the sea through the Colorado. An inspection of the locality discouraged in my mind this bold provision. It seemed to me hardly likely that the operation would meet with success proportionate to the cost in time and labor, and might possibly be the cause of overflows across the peninsula between the two streams, which would bear suddenly into the Lower San Juan more silt than it receives, under present conditions, during several years.

We ran three short lines of levels over the river-banks, two of them on the peninsula, about half a mile below the forks, and one of them at a point on the left bank, where we had ascertained that high floods had been seen to reach on rare occasions. We found the peninsula banks 12 feet and the high flood-level 14.

We observed, in crossing the peninsula from the Colorado to the Lower San Juan, that the land was low and swampy midway, and Mr. Barnes (to whom I have before referred) stated that farther down toward the sea there were extensive interior lagoons. Of course, there is nothing peculiar in this case. It is the general rule in alluvial countries that the highest ground lies close along the river-side. Mr. Barnes informed us that the "*top-gallant floods*" only came over into the interior, and they occur only once in about four years. He said he had on one occasion gone from river to river in his boat about on the line that we had traversed.

It would be so very desirable to have the Lower San Juan turned off at this point, that a careful experiment might be well worth trying. But failing in this, another plan of excluding the *débris* from the Greytown basin will naturally suggest itself, viz, the building of a dam from Punta Arenas to the Greytown shore, across the passes of the delta. Referring to the map, it will be observed that there is a communication between the river and the sea at Harbor Head, besides the Tauro outlet, which lies farther westward. The reduced discharge of the river ought to find these sufficient, or easily made so, without much backing-up of the stream. In connection with the Greytown harbor improvement, the shore to the westward of the jetty and the beach behind it would require arming, as before stated, and communications between the basin and Harbor Head would probably have to be stopped altogether to prevent circulation. A dam then, indirectly connecting the proposed jetty with the main shore, near the village of Greytown, would seem to commend itself as serving many uses.

RECAPITULATION.

Result of foregoing discussion.

1st. The proposed jetty is well located, whether regarded as breakwater only or as a main groin for arresting the moving sands of the coast, and will perform the latter office for twenty years.

2d. This jetty should be built of fascinage as far as practicable and of artificial blocks *pell-mell*, rather than heavier natural stone.

3d. As adjuncts to the jetty proposed, other works will be necessary to arm the beach against the attacks of the sea and give firmness to the abutment.

4th. Should an experiment show that there is no reasonable hope of turning the Lower San

* The shore sand on the west side of Lake Nicaragua resembles that of Greytown beach, especially in its magnetic quality and its general aspect; and we are told that this sand had been used for béton very successfully.

Juan into the Colorado by a more rapid process than nature seems to be attempting, a dam from the jetty to the Greytown shore is proposed as an alternative plan for excluding the river *débris* from the Greytown basin, and incidentally serving other purposes.

URABÁ MOUTH OF THE ATRATO.

The Atrato is a delta river, and may be classed with the Danube, the Nile, the Mississippi, and other streams of great volume, which, coming abruptly upon the sea, tumble over their own *débris* and make their final exits by narrow passes and over shallow banks. The bar of each particular outlet through a delta repeats, in essential respects, the history of the delta itself. The sudden expansion of the outflow and the resistance offered by the inert mass of water outside weaken the stream, so that it not only ceases to scour its channel, but loses the power to carry out the burdens of mud which it has brought from the interior of the country. The case is most aggravated when a tideless river issues upon the sea, presenting a contrast of densities; for in this case, in addition to loss of velocity by expansion and the abrupt meeting with inert water, the fresh water of the river inclines to rise upon the surface of the sea, releasing still more effectually the material that it has previously pushed or rolled along upon its bed. This contrast of density is sometimes the most potent cause of the bar. It is so at the mouth of the Mississippi,* and I believe it is so at the mouth of the Atrato, for, from our own observation, it was found that just within the Urabá pass there was nearly a mile and a half velocity per hour, and that beyond the bar there was still a strong surface current; *but the bar itself lay in the dead angle left below the stream as the latter rose upon the salt-water of the Gulf of Darien.*

The Urabá branch maintains a good depth of water till within 3,000 feet of the sea, and the crest of the bar, upon which there are only 7 feet, is scarcely 200 yards from the line of seven fathoms upon the outside. Our observations upon density were made by lowering down a demijohn from which the cork was drawn when the required depth was reached. It was not the best way to observe, but with considerable care we provided against mixing the waters, I think. I give below our results:

Within the Bar.

Station in middle of stream at the end of the line of vegetation on the banks.

	Sp. gr.	*Temp.*
Surface	0.996	82°
18 feet	0.996	82°

Outside.

About 500 feet from the crest of the bar.

	Sp. gr.	*Temp.*
Surface	0.996	82°
20 feet	1.014	82°
40 feet	1.022	81°

A half mile outside of the bar, we found the water at the surface pretty salt (1.014), and at the depth of 60 feet the full density of the sea, 1.027.

The cessation of the scouring action of the outflow, consequent upon its rising to the surface of the sea, appears to me to be a sufficient cause for this bar, without assuming unwarrantably that there is a large and constant supply of bar-building material in excess of the carrying power of the current.

The Atrato is a turbid river, but there is no evidence, as far as I know, that it carries large amounts of material to the sea. It is true that the map indicates an enormous amount of territory reclaimed, by this river's deposit, from the Gulf of Darien, but "*nature doesn't lack time for anything*", says the proverb, and the question for us is whether nature is working faster than we can. Let us consider this question upon such poor data as we have. While in the Gulf of Darien, I had just a glance at a Spanish chart of 1817 which we found on board of a bungo.† It seemed like a good chart, and I was struck with the close resemblance it bore to the most recent maps. It did not appear that the delta of the Atrato had advanced sensibly during the past seventy years, in which time the Mississippi has advanced its mouth three miles into water vastly deeper than the Gulf of Darien.

* Humphreys and Abbot's Report, page 446. The existence of a considerable tide in a river insures better water upon the bar. Compare the Nile, the Danube, and the Rhone with the Ganges and the Amazon.

† "Quarta hoja que comprende las cartas de la provincia de Cartagena, golfo del Darien." Madrid, 1817.

In the "English Pilot, the Fourth Book, 1872", I have found a brief description of the inner basin of the Gulf of Darien (which Commander Selfridge has named Columbia Harbor). It is called a *salt-water lake, nearly round, ten miles across, with entrance three miles across, twelve fathoms deep, and four fathoms inside.* Opposite the entrance is the "Trato River". Columbia Bay of the Darien report described in similar terms would be thus: *A salt-water lake, oval, ten miles across (east and west) in broadest place; entrance four miles across* (opposite the mouths of the Atrato), *twelve fathoms deep*, with same depth inside. These two statements agree except in the width between the delta and the opposite shore, and in the depth of the basin, both of which are greater now than the English Pilot ventured to state. If we take the distance across the channel, between the 18-feet contours, we make the entrance three and an eighth nautical miles, which is nearer the old Pilot's estimate. One hundred and thirty years have not reduced the area and depth of Columbia Harbor, nor advanced the mouths of the Atrato, we infer.

The velocity at the outflow at the Urabá mouth we found to be nearly one and a half nautical miles per hour upon the surface. This, of course, would be an ample scouring power if it extended to the bottom; but, as we have seen, its influence reaches to but a small depth. Nor have we any reason to suppose that an increase of the discharge would permanently improve the depth of water over the bar. A comparison of the depths at the mouths of the Nile, Rhone, and Mississippi, which differ among themselves very greatly in volume of discharge, does not discover to us any increase of depth dependent upon velocity of outflow. In the case of the Danube, Sir Charles Hartley asserts that "at times of high floods these bars are farther from the shore, their magnitude is considerably increased, and the depths over them are diminished."

Where the supply of material is very large, there would seem to be no use in extending and contracting artificially the banks of the stream, unless, by making one of the mouths a salient to the general sweep of the margin of the delta, a littoral current is encountered which is capable of sweeping away the muds as they are cast down. The hope of improvement in the case of the Urabá seems to me to depend upon the slow supply of bar-building material, and the transverse direction of the current of the gulf that might be reached by extending the river-banks farther out.

The second day of our stay at anchor off the Urabá mouth, Captain McRitchie called my attention to the steady flow of the tidal current, setting north about one knot per hour. We were a trifle over half a mile from the bar and in ten fathoms water. We prepared ourselves the next day to make a set of observations, but unfortunately we found this current did not recur and the outflow of the river extended to the ship,* so that I am unable to state, from systematic observations, that the tidal currents sweep this shore with sufficient velocity to be turned to account. The tides of the Gulf of Darien belong to the same system as those of the Gulf of Mexico, and nothing less than quite a long series of observations would positively enlighten us on the point we have raised. The rise and fall is small, but the relative variation from day to day very large as compared with our Atlantic tides.

There is one quite unfavorable feature exhibited by the map, viz, the most salient portions of the delta are the least bold (compare depths in the parallel of 8° 04′ with those on the parallel of 8° 02′ and 8° 07′), as if the littoral current had done nothing toward maintaining the depths, and the waves considerable toward washing down the bank.

By computation of the tidal currents, I get no velocities through any of the sections over one-tenth of a mile per hour, and our observations of densities preclude the idea that the stream observed by Captain McRitchie was the escape of pent-up river-water.† There may be a flux and reflux dependent upon variations in the force of the trade-winds that blow up the gulf.

Conclusions relative to the improvement of the Urabá.—There being a limited supply of material brought down by the currents of the Atrato, the mouth of the Urabá branch may probably be kept free by dredging.

The artificial extension of the banks as proposed would be useful as a means of protecting an artificial channel, and might perhaps be useful by bringing the deposits of the river within the influence of a littoral current strong enough to sweep them away.

* There was no doubt a flood in the river; the surface density at the ship declined from 1.014 to 1.007.

† On returning to the ship in the afternoon (of the day I have referred to as that of the littoral currents), I found the steamer broadside to a fresh NNW. wind.

BRITO.

This is not a harbor, nor even a roadstead in the strict sense of the word, since there is no shelter from seaward, and the belt of holding-ground along the coast is so narrow that, in heavy weather from the northward, no vessel would venture to seek this anchorage.

At Brito, a broad valley between two ranges of hills stretches down to the coast, where it seems to have once formed a considerable bay, now nearly filled up with alluvia from the wash of the hills and the wear of the adjacent coast. Along the margin of the lowlands, the waves have thrown up a dike of sand (remarkable for the straightness of its alignment), upon the fore shore of which, on the occasion of my visit, there rolled a heavy sea. The largest rollers were estimated at 10 feet height,* and it was observed that these broke almost simultaneously from point to point; so that in one case the breaker presented to our view a cascade more than half a mile in length.

In our studies along the Atlantic coast, we have found the wave angle, in settled weather, quite permanent,—*i. e.*, the direction from which the ground-swell comes to the shore, at any particular point, is the same from time to time, and that the trend of the beach or the movements of the sand, in the long course of time, are in conformity. Where the beach has reached a condition of repose and permanency, we have found its alignment about parallel with the crest-line of the ground-swell. I have, therefore, given a significance to the observations at Brito, and have inferred that a line nearly at right angles to the beach is that of ordinary sea exposure. This exposure may be set down as S. ½ W. (true).

At San Juan del Sur, which is only nine miles from Brito, the breaker upon the beach at the head of the bay is noticeably reduced where the promontory forming the southern point bears to the westward of the direction of wave exposure given above. So, also, in going down the coast, we noticed, on passing within two islands which lay in our course, the bearing upon which we lost the swell, and again the bearing at which we re-encountered it. All the observations gave much the same result, the range being from SSW. to SSE.

I was unable to obtain any information of violent storms upon this coast, and presume they are very rare.† I was told that squalls from seaward occur occasionally in summer, and that there is sometimes a hard blow from the southwest in autumn. Rosser's North Pacific Pilot says that "in July, August, September, and October gales from the northwest occur on the coasts of Guatemala and Nicaragua"; and Imray's "Sailing Directions" mention W. and SW. winds as of "considerable violence in winter", causing vessels to drag their anchors in the roadstead of San Juan del Sur; but I have not met with any ship-captain who remembers encountering strong gales on this coast.

In the plan before me, which is a tracing from the engineer's sheet, I find a harbor projected which consists of a jetty 1,000 feet long, extending from the rocky promontory off the western extremity of the beach, and another jetty opposite the end of the one before mentioned, extending nearly normal to the beach, which is the continuation of the west wall of the portion of the harbor which it is proposed to excavate in the lowland within the present shore-line. The area of the entire harbor is about eighty acres, and the entrance between jetties measures about 1,100 feet.

The criticisms to be made upon this initiatory plan are as follows:

1st. The protection from the sea is insufficient. The longest line that can be drawn across the harbor which shall pass out midway of the entrance has a course very nearly S. by E.; and, from the center of the largest circle that can be drawn within the harbor, the exposure is from S. ½ E. to SE. ½ S. A vessel lying near this central point would be exposed, not only to those rare storms which blow from the southward, but essentially to the continual swell of the sea. Moreover, the site of the proposed entrance to the tide-lock is open to the sea in the direction from which the waves rolled upon the shore on the occasion of my visit.

The area of the harbor is so small, in comparison with the length of the waves and the width of the opening, that every part of it would be in a state of agitation under ordinary circumstances. It will be remembered that the waves of the Pacific, unlike those of the Caribbean, are very long from front to rear, so that even were they cut off from direct access, they would send in and with-

* Others of the party who visited the scene the next day reported much less sea, so that this may be unusual.

† The hurricane of October, 1833, destroyed shipping at Panama. (See Nautical Magazine, vol. iii, page 642.)

draw large masses of water by so broad an entrance, causing a rapid rise and fall. Suppose, for instance, that the mean level length of the wave is 500 feet, its total height 10 feet, and its profile a curve of sines, the volumes of water that would be driven through an opening of 1,100 feet would be over 3,000,000 cubic feet, which would cause one foot minimum fluctuation in the best-sheltered part of the basin. I need not say that this would inconvenience the operations of the tide-gates and the handling of vessels bound in and out of the canal.

Again, the form of the basin is not well calculated to secure tranquillity, even if the area were sufficient. By applying Stevenson's formula for "reductive power" (Encyclopædia Britannica), it will be found that a vessel anchored near the center of the proposed harbor will find the waves only 50 per cent. less than outside of the jetty; *i. e.*, a 10-feet sea will only be reduced to five feet within the harbor.

I submit that the history of artificial harbors, abounding as it does in failures from the causes we have just discussed, teaches us that a harbor to be easy of access and yet tranquil, must consist of an *inner* and *outer* port, the former having a narrow entrance within the shelter of the mole that offers partial protection to the latter.

2d. The proposed harbor is not large enough to accommodate the anticipated fleet of vessels, even if deepened throughout. Making due allowance for a central "gangway" for vessels going to and from the canal, we find room for not more than a dozen ships riding at anchor, allowing each ship four points of swing-room over a radius of 500 feet.

It is much easier to criticise a plan than to propose a better one. The truth is, I presume, that the engineer has been cramped by the conditions of his problem. He has undertaken to project an economical harbor with most of the circumstances of location and exposure against him. He cannot carry his breakwater farther seaward, because the depth of water beyond is too great; and he makes it the continuation of the rocky headland, because here he expects to obtain his supply of material. The one favorable feature at Brito is the lowland lying behind the beach, which is evidently an alluvial deposit which can be easily excavated. This feature the engineer has been quick to recognize, but he has not, I think, availed himself of it to the full extent.

I suggest that the whole scheme be enlarged; that the breakwater be isolated, so as to admit the passage of vessels around either end; and that an inner basin be excavated in the lowland, with a narrow opening placed under the shelter of the aforesaid breakwater. The breakwater may be depended upon to reduce the sea, at the entrance of the inner basin, quite 50 per cent., if it covers the approaches from SE. to SW., and this entrance can be reduced to 300 feet, so as to secure in a basin, say of one hundred acres, the necessary tranquillity.

The laminated clay rock of this coast does not appear to be hard enough for use in exposed portions of a riprap breakwater. The material of the particular headland from which the proposed jetty extends, I did not examine, with the exception of a specimen procured from Commander Lull, which resembled other rocks that I saw on the shore, and is, I think, the same as that found in the neighborhood of San Juan del Sur, where it was observed to contain fossils (rendering it liable to fracture) and to be perforated by borers near the water-line.

Conclusions relative to Brito.—With little to recommend the locality as a site for the construction of a harbor, Brito presents no difficulties unfamiliar to engineers.

The harbor proposed does not promise sufficient protection from the sea, is not of the most approved form, and is too small.

It is suggested that a double harbor will be found necessary in order to secure tranquillity in the receiving-basin near the entrance of the canal; and the office of the breakwater should simply be to shelter the approach to the necessarily narrow entrance of this inner port.

If, in the foregoing remarks upon Greytown and Brito, I have confined myself too exclusively to the *difficulties* presented, it is because I not only felt required by my instructions to observe them, but my attention was particularly called to them by the ingenious commander and the able engineer of the Nicaragua Ship-canal Survey, who acted as our guides.

LIMON AND CHIRI-CHIRI BAYS.

It has been proposed that either Limon or Chiri-Chiri Bay should be the terminus of a canal from the Atrato River to the Pacific Ocean. Considerations relative to interior work, especially in

connection with the length of a proposed tunnel, have given to Chiri-Chiri Bay the preference, although Limon Bay is much better adapted naturally to conversion into a suitable harbor.

General exposure.—The voyager along the Pacific coast of the isthmus, below Panama, may be struck with the entire absence of any traces of the action of violent storms and flying seas. The land-slides upon the bold cliffs of Punta Crucis seem rather to have resulted from the original steepness of the hills than from the dash of the sea, although the continual wear of the regular breaker has no doubt undermined them and let down the superincumbent earth. I have particularly referred to Punta Crucis, because it is a promontory extending into the sea and exposed to whatever degree of violence the ocean may attain. Yet, passing around this spur of land, we observed that the forest extended in some places within 30 feet (estimated) of the plane of high water. Under similar circumstances of exposure on our New England coast, the destructive traces of the waves are followed by the most careless eye to the height of 70 feet, and the lantern of Minot's Ledge light-house is sometimes enveloped by a flying sea, although it has been placed 92 feet above the ordinary level of Boston Bay.*

On the other hand, while we look in vain for the traces of storms along the Pacific shore of the isthmus, we could but observe everywhere the great length and height of the *ground-swell* that rolls in from the ocean. The day that we reached the shore of Chiri-Chiri, we estimated the occasional height of the breaker at seven feet, and Captain Pattison, of the Saranac, informed us that a day or two previous the roll had been so great that he did not consider it safe to lower away boats.

We may conclude that, in considering the project of a harbor upon this coast, we have only to provide for an adequate stilling-basin and proper shelter in its approach against the roll of the sea. In the few days that we remained upon the coast, this roll was observed to come from the SSW. At our first landing-place, in Capica Bay, we found that, with the outer rocks of Punta Crucis bearing about S., the breaker on the shore was reduced by this shelter to about 2 feet, and here the vegetation upon the shore extended to within 4 feet (estimated) of the plane of highest tides. At Limon Bay, under the shelter of the reef, which extends from the southern side of the basin, the breaker was reduced to about 3 feet, and at Chiri-Chiri Bay there seemed to be a slight reduction of the breaker as we walked along the strand to the southward, bringing the reef below the mouth of Chorito River to bear westward of SSW.

Limon Bay.—This cove is about half a square mile in area within the chord that passes through eight fathoms of water (see sheet No. 1 of the Darien Report). In the southern part, we have five fathoms of water at a point from which one cannot see the open ocean. A reef near at hand offers shelter from the westward, and shuts by the extremity of Punta Crucis, which is seen in the distance. Without further protection, however, this could not be made the terminus of a canal and the receiving-basin for ships, because of the swell to which I have already referred.

It would not be difficult to convert a portion of the cove into a tranquil basin by inclosing a sufficient space by sea-walls, and providing a narrow entrance under the lee of the reef before mentioned, or the same extended.

If an ordinary trading-port were contemplated, the simplest plan would be to extend moles from either shore along the chord of the cove; but the broad opening that would be necessary to insure safe and easy access would admit too much sea for a canal-harbor.

Chiri-Chiri Bay.—Here we have a bend in the coast, exposed to the swell of the ocean, with no features which could recommend it as the site for the construction of a harbor, except a narrow belt of anchorage-ground, which has "good holding-ground of clay, in twenty fathoms, three-quarters of a mile from the beach", and an immunity from storms. These exceptions to the unfavorable conditions of the site would be all-important if we contemplated only an ordinary trading-port; but we have, as I have stated before, to provide for reducing the sea at the quays and gates of a canal-entrance, and this, I submit, can only be done by the construction of an *outer* and *inner* port. The case is similar to that of Brito, already discussed at length, except that here at Chiri-Chiri we find no low country behind the beach from which an inner basin can be excavated; both the inner and outer basins must be constructed in the narrow belt of ground lying between high-water line and perhaps the eight-fathom curve.

* Captain Tower, Superintendent of Repairs, Light-house Establishment, is my authority.

If we assume that material will be abundantly supplied from the canal cutting, we may suppose that the breakwater can be built in eight fathoms at low water, which would be ten fathoms at ordinary high water. This structure would have to be placed within about 1,500 feet of the shore; and, in order to get the necessary areas for the two basins, this mole would have to be nearly a mile long, with a return-wall to the beach at its southern end.

The pier-head of the mole I have conceived as situated in eight fathoms of water off a point on the shore three-fifths of a mile northwestward of the mouth of Chiri-Chiri River. Here the distance across from the pier-head to the present eighteen-feet curve would be a thousand feet, which might suffice for the entrance of a ship under tow of a steamer. That the approach should be from the northward seems obvious, when we consider the direction of the swell and the shelter from wind offered by the land. I have conceived of the stilling-basin as having an entrance through a bulkhead wall close under the lee of the mole, and not less than 2,000 feet from the pier-head. If we conceive of the return-wall, at the southern end of the mole, as extending from the larger of the two rocky islands on the strand below the outlet of Chiri-Chiri River, we can have a surface-area of still basin amounting, perhaps, to a hundred acres, which is no larger than it should be.

We may reckon upon a wave reduction of over 50 per cent. in the outer basin; and if the entrance to the inner basin is reduced to 300 feet, the necessary quiet will be secured near the proposed entrance to the canal. The height to which the mole need be carried is not great. We found vegetable mould still clinging to the rocks sloping to the sea within 15 feet (estimated) of the plane of highest tides.

Conclusions relative to Limon and Chiri-Chiri Bays.—There would be little difficulty in converting Limon Bay into a proper harbor for the terminus of a ship-canal; but Chiri-Chiri Bay presents scarcely any natural qualifications to become the site of a port.

In order to secure the necessary quiet at Chiri-Chiri, a mole nearly a mile long seems requisite, and this lying, of necessity, nearly parallel to the shore, and within a quarter of a mile of it, would be a difficult shelter to reach in safety, sometimes, even under steam towage.

APPENDIX No. 13.

ECONOMY IN COAL, AS EXEMPLIFIED BY THE ACTION OF COMPOUND ENGINES IN THE UNITED STATES COAST SURVEY STEAMER HASSLER, REPORTED BY CHARLES E. EMERY, CONSULTING ENGINEER.

I transmit herewith an abstract of the engineer's journal of the United States Coast Survey steamer Hassler, with tabulated results founded thereon, showing the performance of the steam-machinery at sea, under conditions substantially uniform, but, on the whole, more unfavorable than in ordinary practice. The abstract is made from the record of the run from Panama to San Francisco in July and August of the year 1872, that being the first time, after the engineers were furnished with complete blank journals and careful instructions suggested by former experiences, that the vessel was under steam for a sufficient period to furnish reliable information.

The steamer had just come from the Atlantic coast; consequently some matters were out of repair,—for instance, a defective stuffing-box caused a poor vacuum, and a leaky tube in the condenser required the use of some salt-water, both faults reducing the economy; so also the iron bottom of the vessel was very foul, which reduced the speed.

The steaming for the time included in the abstract was made at half boiler-power, which should have given, with clean bottom, an average speed of 7½ to 8 knots under the conditions encountered.

Stops were made in various ports for sounding and dredging purposes during the trip, so the abstract has been divided into five runs, designated by letters, during each of which the conditions were substantially uniform and the steaming continuous, except one stop for dredging in each of the two first; in these, the whole watch of four hours, in which the stop was made, has been rejected, to secure the condition of uniform operation. The other columns will be understood from the headings. Following the abstract, I give a brief discussion of portions of the same with references to other performances of the vessel. I also append for reference a short description of the vessel and machinery.

The following extracts from the instructions printed in the engineer's journal will show the precautions taken to obtain accurately the power developed and its cost in fuel:

"The steam-pressures, vacuum, and positions of throttle and cut-off, as recorded, should be the means for the hours, and not simply correct records at the time of the observation. In case that, by order or accident, the average conditions are abruptly changed during the hour, interlined entries should be made showing the average for each period, and the exact time of the change be noted in the remarks.

"A complete set of indicator-diagrams should be taken at least once every day: for instance, shortly before the meridian, at which time the position of the cut-off, throttle, and the steam-pressure, and other conditions should be regulated so as to represent, as nearly as possible, the average for the steaming done during the previous twenty-four hours. The diagrams necessary for a complete set should all be taken as nearly as possible at the same time, and the data provided for in the specimen diagram herein be collected and noted without delay. The diagrams and data should show the facts as they exist at the time, the object not being to obtain a maximum result or fair-looking diagrams. The original diagram should be slightly secured with mucilage at its upper left-hand corner, between the pages of corresponding date in the original journal. When experimenting, diagrams should be taken half-hourly, in which case the name of the vessel and the date and time need only be noted thereon, and the other quantities can be obtained from the journal.

"The reading of the engine-counter should be taken exactly at the end of the hour by observing the second-hand of the clock in connection with the other hands.

"The net amount of coal used should always be entered in the log. To check errors, the bunkers should be carefully measured when empty and drawn to scale, and after every fifteen days'

steaming, and just before coal is received, the coal in the bunkers should be trimmed to regular slopes, the amount measured and calculated, and the coal account corrected by an additional entry under the daily balance, as follows: 'Remaining, as per measurement this day, ——— pounds.' The plan of adding a percentage to each day's expenditure, or of charging for ship's use extraordinarily large amounts, is disapproved. The log should in all respects show facts as accurately as they can be ascertained; hence every deficiency or surplus should be recorded as soon as it is discovered, and the account adjusted at once."

During a previous voyage, the commander of the vessel, to satisfy himself as to the accuracy of the coal account, had issued an order that the bunker-doors be locked and opened only once in the watch in the presence of the engineer, when the coal for a watch was to be measured out. This system was productive of such good results that it was continued, in connection with periodical measurements of the bunkers. Such measurement was made August 6, and again August 21, and a deficiency in the coal account found amounting to 6.008 per cent., which could be easily accounted for by the few lumps that fell on the floor in measuring the buckets. This percentage was in later trials much reduced; but, not to overstate results, the amounts in column marked "Coal per hour by journal" have been increased 6 per cent., and the augmented or actual amounts, recorded in the next column, have been used in the final determination of the cost of the power.

The above shows that, even with a comparatively small compound engine of good construction, each indicated horse-power can be obtained, on regular duty at sea, for 1¾ pounds of coal per hour, or less than half that required with ordinary marine machinery of the old type, and hardly two-thirds that used, according to best testimony available, in the better class of large, direct-exhausting marine engines using high-pressure steam.

This cannot be called an experimental result. In fact, the unfavorable conditions mentioned prevented it from being the maximum for regular sea duty. There is every reason to believe that, with careful attention, and both boilers in use, a result could have been obtained of one and a half pounds of coal per horse-power per hour. In fact, some previous runs show this performance; but as they were made before the coal account was checked regularly by the bunker measurement, the results are not given in detail. There is, however, no reason to doubt their accuracy.

The vessel on her trial-trip, using Schuylkill coal and both boilers, developed 125 horse-power with 250 pounds of coal per hour, a performance of 2 pounds of coal per horse-power per hour when the boiler and engines were not felted and the weather quite cold. The firemen, too, were not accustomed to the slow combustion obtained by using two boilers, and much watchfulness was required to insure regulation by the dampers instead of by opening furnace-doors. This difficulty caused a very great waste of fuel afterward, when it was attempted to run moderately with both boilers on regular duty at sea, and, finally, it was actually found, in practice, that unless an engineer was kept constantly in the fire-room, it was far more economical to *force the fires* under one boiler at slow speeds than to use slow combustion in two boilers.*

Only one boiler was in use during the runs set forth in the foregoing abstract.

The following extracts, from the official report of Commander C. Johnson, U. S. N., commanding the Hassler, may, I think, be considered in place in this report:

"It gives me pleasure to request notice of the consumption of coal while engaged in such work as the Hassler was designed for. At San Diego, before starting the fires, the ship had in her bunkers 101.09 tons.

	Tons.
"To-day	68.30
Deduct for distilling water, galley, stoves, etc	3.60
Showing a consumption in thirty-five days of	29.19
Averaging per day	0.83

"The ship has been under steam every moment since leaving San Diego. Excepting Sundays, she has been under way during the day, and banked fires at night, having steamed 1,069 miles, and

* An attempt is being made, however, to secure the economy due to increased heat-absorbing surface, by using both boilers and reducing the grate-surface with fire-brick. So far it has been found that the steam can be carried more steadily, but no accurate determination can be given in regard to the question of economy.

made 707,026 revolutions. The bunker-doors are closed and locked at all times (except when in the act of getting out coal), and the key always in possession of the engineer. Besides weighing, the bunkers are frequently examined and their contents measured."

In a subsequent letter, Commander Johnson writes:

"We have been fifty-eight days under steam, running from daylight till dark generally; banked fires at night and Sundays; and have consumed in the furnaces only 1891.4 pounds of coal per twenty-four hours, or 0.844 of a ton per day.

"There is no mistake about it. There has been no stealing of coal. The bunker-doors were locked except when serving out, and the measurement shows the proper amount on hand now."

I submit that the above facts are sufficient to show conclusively the great economy which may be obtained by the use of the compound engine.

For convenience of reference, a general description of the Hassler is hereto annexed.

General description of the United States Coast Survey steamer Hassler.

The Hassler is an iron screw-propeller of 350 tons burthen old measurement. She was built at Philadelphia in the year 1871, and is 151 feet long on load-line, and has 24½ feet breadth of beam and 10 feet depth of hold. Her rig is that of a three-masted schooner, with lower masts of moderate length and tall topmasts. The officers' quarters are on deck, and are very commodious.

The vessel is propelled by a compound engine of 200 horse-power. The cylinders are 18.1 and 28 inches in diameter by 26 inches stroke, and are arranged one above the other in the same line, with both pistons on the same rod, and operating the crank through a single connecting-rod. The steam-chests extend beyond the ends of the cylinders, to reduce the length of the cylinder-ports; but, for simplicity of construction, the valve-face of the upper cylinder is brought out in line with the other, and the valves of both cylinders are operated by the same rods. The upper cylinder is supported from the framing by four wrought-iron columns, and the two cylinders are sufficiently separated to allow the cover of the lower cylinder to be raised to obtain access to the piston. The bed-plate is made of sufficient length to receive three bearings, in addition to which an independent thrust-bearing is connected to the same. The surface-condenser is arranged under one side of the frames, and slants inward at the same angle as the latter. The circulation is performed by a centrifugal pump, driven directly by a small engine. The air- and feed-pumps are vertical, and receive motion from the main cross head through beams in the usual way. The necessary valves are provided so that live steam can be excluded from the upper cylinder and supplied direct to the larger one if desired. Ordinarily the steam passes to the upper cylinder, in which it is cut off at such point as to give the power desired, or usually at less than half-stroke. The steam then passes to a large reservoir, placed under the main deck, through which it traverses slowly, thus permitting the water due to condensation for the work done to become separated. From this reservoir, the steam passes to the lower cylinder, but the supply is suppressed therein at such point as to keep the pressure in the reservoir substantially uniform. The lower cylinder communicates with the condenser in the usual way. The large cylinder and its bottom and head are steam-jacketed. Drip-vessels with glass gauges are provided to assist in blowing the condensed water from the jacket and reservoir. The propeller is a true screw, 8 feet 6 inches in diameter, with 13 feet pitch. At the hub, the blades are rounded on both sides to reduce the resistance where the metal is thickest. The flat propelling surface gradually widens from the hub outward to 4 feet diameter, and the outer portions of the blades are of the ordinary construction.

Steam is supplied by two flue and return tubular boilers, each 6 feet in diameter and 12 feet long, and provided with a steam-chimney. The total grate-surface is 42 square feet and the total heating-surface 1,400 square feet.

The shells are ⅜ inch thick, with double-riveted longitudinal seams. All flat surfaces are stayed 6 inches between centers. The boilers are considered of sufficient strength to carry regularly 80 pounds pressure for a series of years.

The maximum speed of the vessel, under steam alone, is 9½ knots. Under steam and sail, she has made easily 10 and 11 knots. The ordinary speed at sea, under steam alone, is restricted, by order, to 8 knots, which can be obtained with one boiler under favorable circumstances.

It will be of interest to add, in this connection, that the first reports as to the performance of the Hassler were unsatisfactory, owing to very bad management in the engineer department. The vessel left the Atlantic coast in the fall of 1871; and as her commander found it necessary to take coal much sooner than was expected from results obtained on the trial-trip, he instituted an investigation, which had the effect eventually to make the performance all that could be desired, and to interest all on board in the matter, so that in fact a number of naval officers, then attached to the vessel, but who have recently returned to the East, have expressed a desire that the actual facts as to the vessel's later performances should be made public.

APPENDIX No. 14.

DEVICE FOR DETACHING FROM A LINE THE HEAVY WEIGHT REQUISITE IN DEEP-SEA SOUNDINGS BY LIEUT.-COMMANDER C. D. SIGSBEE, U. S. N., ASSISTANT COAST SURVEY.

OFFICE OF THE UNITED STATES COAST SURVEY,
Washington, D. C., October 10, 1874.

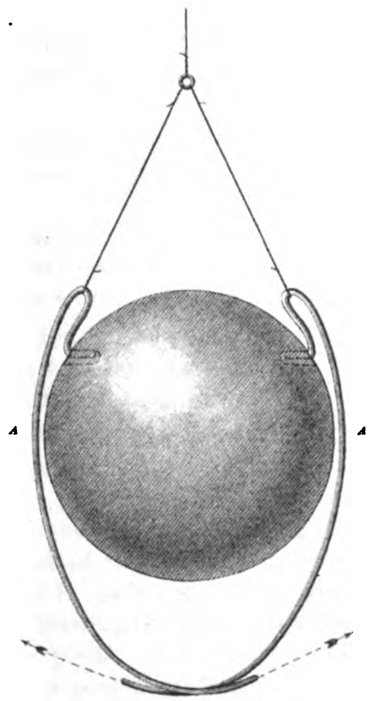
SIR: I would respectfully present for your examination a new plan of detaching shot in deep-sea soundings. The apparatus, as shown in the annexed figure, differs from anything that I have seen, and, from its simplicity, could be manufactured on board any vessel carrying shot, the cost being so trifling as scarcely to be considered. The accompanying lithograph, after a drawing, shows the apparatus attached to a shot. It consists of two wires, one end of each being bent to form a "cant-hook", and the other and longer end being bent around and carried under the shot, and at a distance below it equal to about one-third of its diameter. The parts which enter the holes in the shot should be as short as will suffice to support the weight. If either hook trip, the other must follow. I have experimented with the apparatus when attached to a grape-shot—such as is used in an 11-inch gun—and it worked satisfactorily on any kind of bottom. Its first failure to detach was in soft mud, or ooze, which entirely covered the shot. On hauling up, the bare ends of the hooks were just inside the holes. I cut off half the length of the hooks, after which the apparatus, on all occasions, detached perfectly when bottom was reached, and supported the shot with certainty when lowered quickly against the surface of the water a number of times in succession. Should it be found to fail in strong currents, three wires might be hooked at equal distances around the shot; and if the holes in the shot be beveled from the sides, the tripping of one hook would detach the others.

I am, sir, very respectfully, your obedient servant,

C. D. SIGSBEE,
Lieutenant-Commander United States Navy, Assistant Coast Survey.

CARLILE P. PATTERSON, Esq.,
Superintendent.

No. 23



Handy Method of Detaching Shot
in Deep Sea Sounding

Proposed by Lieut. Comdr. C.D. Sigsbee U.S.Navy
Assist Coast Survey

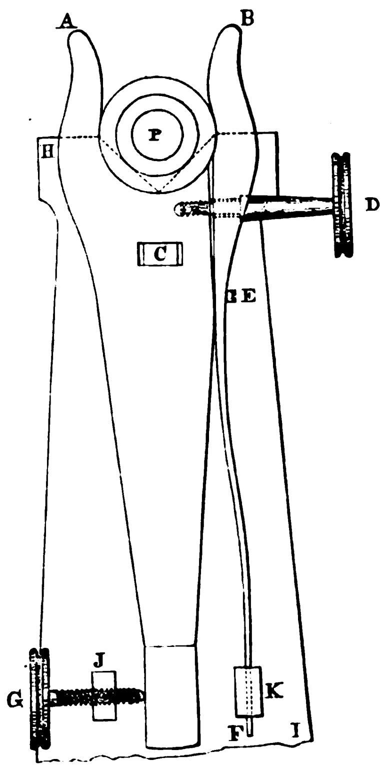
The wires should be close to the shot at the points A A and so bent that the lower ends on striking bottom will be forced in a direction indicated by the arrows.

APPENDIX No. 15.

IMPROVED CLAMP FOR THE TELESCOPE OF THE THEODOLITE.

COAST SURVEY OFFICE,
Washington, May 4, 1874.

DEAR SIR: Having experienced much inconvenience with the ordinary clamp and movement for vertical motion of the telescope of the theodolite, especially when reversing for azimuth, I, last season, devised a method of clamping, which possesses all the good qualities of the ordinary clamping and does away with its bad qualities.



I. The telescope is clamped with sufficient firmness to admit of its being moved in the vertical plane by means of the tangent-screw.

II. The top of the clamp is open so that it permits the telescope to be lifted out for reversal, and placed again in the Y's without carrying the clamp with it.

III. By adjusting the spring, the clamp may be made to hold the pivot so gently that a very delicate tap on the telescope will bring the latter to the desired elevation.

The accompanying wood-cut will exhibit its peculiarities. H I is one of the transit-axis supports or pillars, with end of pivot in Y. A is a rigid bar, about $\frac{1}{4}$ or $\frac{1}{3}$ inch wide, held in position by the small bar C, secured to the pillar, and passing loosely through a slot in A, and by the end of the spring F passing through the projection K from the pillar I. B is a spring secured to the bar A at E. D is the screw for drawing the spring B toward the bar A, and thereby clamping the pivot. G is the screw giving movement in the vertical. J is a projection from the pillar.

This clamp may be placed outside the pillar on the free end of the pivot of the transit-axis, or inside the pillar on a collar of the transit-axis.

Yours, respectfully,

GEORGE DAVIDSON,
Assistant, United States Coast Survey.

Mr. C. P. PATTERSON,
Superintendent Coast Survey, Washington, D. C.

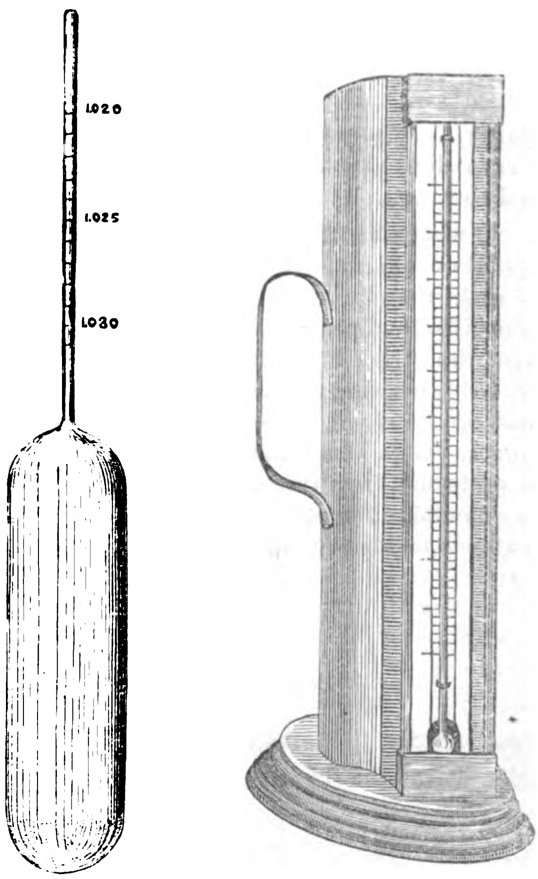
This clamp applies equally well to the transits in use on the Survey.—D.

APPENDIX No. 16.

DESCRIPTION OF AN OCEAN SALINOMETER, BY J. E. HILGARD, ASSISTANT UNITED STATES COAST SURVEY.

The density of sea-water in different latitudes and at different depths is an element of so great importance in the study of ocean physics as to have caused a great deal of attention to be paid lately to its determination. The instruments employed for the purpose have been, almost without exception, areometers of various forms. The differences of density as arising from saltiness are so small, that it is necessary to have a very sensitive instrument. As the density of ocean-water at the temperature of 60° Fahr. only varies between the limits of 1.024 and 1.029, it is necessary, in order to determine differences to the hundredth part, that we should be able to observe accurately the half of a unit in the fourth decimal place. This gives a great extension to the scale and involves the use of a series of floats if the scale starts from fresh water, or else the instrument assumes dimensions which make it unfit for use on board ship.

With a view to the convenient adaptation to practical use, the apparatus figured below has been devised for the Coast Survey by Assistant Hilgard.



The instrument consists of a single float about 9 inches in length. The scale extends from 1.020 to 1.031, in order to give sufficient range for the effect of temperature. Each unit in the third place, or thousandths of the density of fresh water, is represented by a length of 0.3 of an inch, which is subdivided into five parts, admitting of an accurate reading of a unit in the fourth place of decimals by estimation. The float is accompanied by a copper can, with a thermometer inserted within the cavity, which is glazed in front. In use, the can is nearly filled with water, so as to

overflow when the float is inserted, the reading being then taken with ease at the top of the liquid. For convenience and security, two such floats and the can are packed together in a suitable case, and a supply of floats and thermometers, securely packed in sawdust, is kept on hand to replace the broken ones.

The following table has been derived from the observations of the expansibility of sea-water made by Prof. J. S. Hubbard, U. S. N. Column II contains a table of reductions for temperature of salinometer readings to the standard of 60° Fahr. To facilitate the use of this table, the following directions are given.—

Record the actual observation of hydrometer and thermometer. From Column II (which is applicable for any degree of saltiness within the given limits) take the number corresponding to the observed temperature, and multiply this number by the number of degrees and fractions of a degree that the observed temperature differs from 60°. Apply this product as a correction, with proper sign, to the reading of the salinometer, and the result will be the reading of the salinometer at the standard temperature of 60° Fahr.

Example.—Actual reading of thermometer = 80°.5; actual reading of salinometer = 1.02425.

Opposite 80°.5 in Column II is +0.0001585, which multiplied by 20.5 gives as a product +0.003249. Add this to the observed reading of salinometer, and 1.02750 will result as the reading of the salinometer at the standard temperature.

Temp.	Coeff. for reduction to 60°.	Temp.	Coeff. for reduction to 60°.	Temp.	Coeff. for reduction to 60°.	Temp.	Coeff. for reduction to 60°.
°		°		°		°	
50	−0.000108	60	+0.000000	70	+0.000145	80	+0.000158
51	−0.000110	61	+0.000130	71	+0.000146	81	+0.000159
52	−0.000112	62	+0.000135	72	+0.000147	82	+0.000160
53	−0.000113	63	+0.000137	73	+0.000148	83	+0.000162
54	−0.000115	64	+0.000137	74	+0.000149	84	+0.000163
55	−0.000118	65	+0.000138	75	+0.000151	85	+0.000164
56	−0.000120	66	+0.000140	76	+0.000152	86	+0.000166
57	−0.000120	67	+0.000141	77	+0.000154	87	+0.000167
58	−0.000120	68	+0.000142	78	+0.000156	88	+0.000168
59	−0.000120	69	+0.000143	79	+0.000157	89	+0.000170

A method quite different in practice for determining the density of sea-water has been suggested by Prof. Wolcott Gibbs, of Harvard University. It depends upon the determination of the index of refraction by means of an angular instrument similar to the sextant. As all navigators are familiar with the use of the sextant, and as the observation can be made without hinderance from the motion of the ship, this form of the instrument may be found to possess certain advantages.

NOTE IN 1876.—When the table of reductions for temperature above given was constructed, the investigations relative to the same subject made by Thorpe and Rücker (Royal Society's Proceedings, January, 1876) were not known. The following comparison of the results of the experiments on the thermal dilation of sea-water, as taken from Professor Hubbard's tables and as derived from the results of Thorpe and Rücker, show the differences within the range of temperature covered by our table of corrections:

Temperature.	Volume.	
	Hubbard.	Thorpe and Rücker.
°		
50	0.99895	0.99902
55	0.99943	0.99946
60	1.00000	1.00000
65	1.00067	1.00059
70	1.00142	1.00127
75	1.00221	1.00205
80	1.00309	1.00280
85	1.00402	1.00364

APPENDIX No. 17.

DESCRIPTION OF TWO FORMS OF PORTABLE APPARATUS FOR THE DETERMINATION OF PERSONAL EQUATION, BOTH RELATIVE AND ABSOLUTE, IN OBSERVATIONS OF STAR TRANSITS, BY J. E. HILGARD, ASSISTANT UNITED STATES COAST SURVEY.

It has long been apparent that the precision of instruments used in the determination of astronomical time exceeds, both in accuracy and constancy of performance, the physiological powers of the observer, to whose variability is due a large proportion of the probable error of results. This has been especially felt in the determinations of longitude made by the telegraphic method, in which we find, on different nights, variations in the results which far exceed the apparent uncertainty of the determination of time, and of the transmission of signals. We also find that, when observers compare their method of observing directly, while their personal equation appears in a great degree constant on any one occasion, it will differ on another occasion by an amount far exceeding the uncertainties of determination.

It has, therefore, long been felt as a great desideratum to have some convenient means of determining the personal equation of an observer at the time of the observations for longitude. If each observer possessed a similar instrument to which he could refer himself, and which was so exact in its adjustment that the same conditions could always be produced within the limits of accuracy demanded, the result of each night's work could be referred to a standard equation. This would preferably be the absolute equation, or that by which the observations of each observer are referred to that instant of time at which they would be recorded if no time elapsed between the passage of a star and the record of the passage.

Various instruments have been devised by different observers for the determination of absolute personal equation. It has been found that the phenomena to be observed should be very closely imitated, in order to make the equation so obtained applicable to the actual case, inasmuch as its amount will differ in the same person, according to the character of the phenomena observed, and the means by which the time is noted or recorded. In order to make the method applicable to star-transits, it is, therefore, desirable that an artificial star should be made to traverse the optical field in which it passes over a system of lines similar to that used in actual observations. It cannot even be deemed quite admissible that this should be done with only a single line, but at least five should be used. The most desirable arrangement appears to be that of making an artificial star-image traverse alternately in opposite directions the field of a collimating telescope, a system of electrical contacts being so adjusted in connection with the mechanism that a record is made of the instant when the image of the star passes the several lines in the field of the collimator. A few transits of this sort, automatically recorded, and likewise observed and recorded in the usual manner at the beginning and end of each night's work, will make the observer's results at different times more nearly comparable than they are now, and likewise comparable with the results of other observers; and we may anticipate that hereafter such an apparatus will be deemed a necessary part of the outfit of a permanent observatory. Some years ago a rudimentary arrangement of the kind was used by Professor Winlock, at Harvard College Observatory, but the movement of the star-image was not effected by mechanism but by the hand of the observer with the aid of a long lever. Such a movement, of course, lacked uniformity, and as no results have ever been published we may assume that they proved unsatisfactory.

In 1873, the writer caused to be constructed at the Coast Survey Office a personal-equation apparatus on the same plan, intended for field use. In this it was designed that any residual error in the adjustment of the electrical contact relative to the coincidence of the star-image with the line should be eliminated by the alternate movement from right to left and left to right. The

apparatus, however, failed to give results of sufficient accuracy, partly from mechanical defects in the construction, but chiefly owing to the small linear dimensions of the line-intervals, which rendered it impracticable to obtain sufficient precision for the automatic record of the passages. It was then decided to adopt a field in which the space represented by a second of time should be sufficiently great to admit of its subdivision to one hundredths of a second with a perfect facility. The instrument figured in the plate, Form I, and described below, was, in consequence, devised and constructed by Mr. Werner Suess, under the immediate direction of the writer.

In this exceedingly compact apparatus the passage of an artificial star across the middle transit-line can be registered to furnish, in connection with its observed transit, a measure of the absolute personal equation of an observer. For the automatic registration, the clock (or chronometer) breaks, and the automatic breaks, as the star passes, each of the five lines, are in one electric circuit, while the breaks for the apparent transit, by the observer, are effected through a second circuit, the two showing their marks on the same chronographic sheet, and side by side. The rays of light of an ordinary coal-oil lamp are conveyed to a focus and shown through a fine pin-hole (*t*) in a diaphragm inserted in a tube (B) which is moved to an fro by clock-work. A lens (*u*) at the other end of the tube throws the image of this hole on the ground-glass plate (*a*) on which are engraved five lines representing the threads of a transit-instrument. These lines are in the focus of the lens. Corresponding to these are five steel points, on each of which, in succession, by the motion of the tube, the electric current is momentarily broken and instantly restored. The observer operates by means of an ordinary break-circuit key, and one or two observers may note the transit at the same time through ordinary opera-glasses.

To effect the adjustment for absolute equation, a fine-motion screw (*g. r.*) is provided which controls the instant of contact break, and the star at rest is accurately bisected on the center transit-line by means of a second fine-motion screw (*e*) acting on the glass diaphragm and imparting to it a small horizontal motion. During this adjustment the clock-work is disconnected from the tube, as shown by the dotted lines of the carrier (*n*). The other transit-lines serve to determine, *differentially*, the personal equation of two observers.

The important peculiarities of this new appparatus are as follows:

(1). It is easily portable, weighing only eight pounds.

(2). The circuit-break (shown by *b*, *c*, *d*, *e*, *f*) can be so adjusted that the star appears either before or after the breaking of the current, thus requiring only one pen for the observations, a very important point when used in the field.

(3). As the star appears on the the transit-lines without parallax, two or more observers can observe the transit of the star over the lines at the same moment, each one using his own chronograph and chronometer, thus giving the means for a differential comparison of their personal equations.

Following is an abstract of results obtained with this instrument. Merely the *difference* between the automatic breaks and the observer's breaks is given, the absolute times being of no consequence.

COAST-SURVEY OFFICE, *May* 20, 1874.

Apparatus arranged for differential observations.

Observer, Professor Eastman, United States Naval Observatory.

Apparent motion of star from left to right.*

	Set 1.	Set 2.	Set 3.	Set 4.	Set 5.	Mean.
	s.	*s.*	*s.*	*s.*	*s.*	*s.*
I	0. 16	0. 48	0. 22	0. 22	0. 31	0. 278
II	. 15	. 30	. 25	. 31	. 30	. 262
III	. 60	. 65	. 60	. 62	. 66	. 626
IV	....	....	....	....	....	....
V	0. 14	0. 19	0. 10	0. 22	0. 19	0. 168

Star moving from right to left.†

	Set 1.	Set 2.	Set 3.	Set 4.	Set 5.	Mean.
I	0. 50	0. 59	0. 70	0. 60	0. 50	0. 578
IV	. 60	. 82	. 87	. 81	. 71	. 762
V	0. 78	0. 95	0. 85	0. 68	0. 77	0. 806

Observer, Mr. Frisby, United States Naval Observatory.

Star moving from left to right.

	Set 1.	Set 2.	Set 3.	Set 4.	Set 5.	Mean.
I	0. 18	0. 20	0. 26	0. 33	0. 23	0. 240
II	. 13	. 21	. 33	. 31	. 25	. 246
III	. 44	. 61	. 50	. 57	. 59	. 542
V	0. 06	0. 20	0. 17	0. 18	0. 14	0. 150

Star moving from right to left.

	Set 1.	Set 2.	Set 3.	Set 4.	Set 5.	Mean.
I	0. 41	0. 81	0. 66	0. 46	0. 58	0. 584
IV	. 47	. 80	. 74	. 60	. 81	. 684
V	0. 40	0. 55	0. 61	0. 70	0. 81	0. 614

Observer, Mr. Smith, United States Coast Survey.

Star moving from left to right.

	Set 1.	Set 2.	Set 3.	Set 4.	Set 5.	Mean.
I	0. 28	0. 18	0. 24	0. 23	0. 19	0. 224
II	. 32	. 20	. 30	. 28	. 30	. 280
III	. 69	. 71	. 62	. 59	. 76	. 674
V	0. 25	0. 29	0. 29	0. 14	0. 04	0. 202

Star moving from right to left.

	Set 1.	Set 2.	Set 3.	Set 4.	Set 5.	Mean.
I	0. 69	0. 62	0. 67	0. 62	0. 58	0. 636
IV	. 96	1. 02	. 91	. 91	. 99	. 958
V	0. 80	0. 69	0. 80	0. 70	0. 84	0. 766

* Indistinct on line IV. † Indistinct on lines II and III.

RECAPITULATION OF RESULTS, EACH FROM FIVE SETS OF OBSERVATIONS.

Star moving from left to right.

	Obs'r.	Transit at–	E. – S.	F. – S.
I	E*....	+0. 278	+0. 054	+0. 016
	F....	. 240		
	S....	. 224		
II	E....	+0. 262	–0. 018	–0. 034
	F....	. 246		
	S....	. 280		
III	E....	+0. 626	–0. 048	–0. 132
	F....	. 542		
	S....	. 674		
V	E....	+0. 168	–0. 034	–0. 052
	F....	. 150		
	S....	. 202		

Star moving from right to left.

	Obs'r.	Transit at–	E. – S.	F. – S.
I	E....	+0. 578	–0. 058	–0. 052
	F....	. 584		
	S....	. 636		
IV	E....	+0. 762	–0. 196†	–0. 274†
	F....	. 684		
	S....	. 958†		
V	E....	+0. 806	+0. 040	–0. 152
	F....	. 614		
	S....	. 766		

* The plus (+) sign indicates that the automatic break precedes the observer's break. † Rejected.

Difference of personal equation, mean of thirty transits:

$$E. - S. = -0.010 \pm 0.013$$
$$F. - S. = -0.068 \pm 0.016$$
$$E. - F. = +0.060 \pm 0.017$$

The sign (+) indicates first observer later, that is, giving more chronometer-time than the second.

An apparatus of this kind was taken to Paris by Mr. Hilgard, in September, 1874, and presented by Mr. Tresca to the Academy of Sciences on November 2 (Comptes Rendus, No. 18, vol. 69).

While the apparatus just described serves admirably the purpose of determining the relative equation of two observers present at the same time, it yields the absolute equation only on one line in each transit. It cannot, therefore, be held to satisfy in a sufficient degree the requirement that, each observer being furnished with a similar apparatus, observations made by different persons at different points should be made strictly comparable by its means. The writer, therefore, directed the construction of another instrument on substantially the same plan, but in which the transit over each line should be adjustable, so as to give the absolute personal equation. Assistant C. A. Schott kindly undertook the immediate supervision and criticism of the details of construction, which were, as before, executed by Mr. Suess. The apparatus figured in the plate, Form II, was the result. It may be briefly described as follows:

This second form differs from the first in having all of its threads adjustable. Otherwise, it is constructed on the same plan as the one just described. It is equally portable, and the electric circuits are the same as in the first form. The lamp, as well as the clockwork (not shown in diagram) giving motion to the tube, is outside the box. To adjust the instrument, a fine motion is provided for the tube (the clock-work being first thrown out of gear), and the exact bisection of the image of the star is made on the first thread. Next, the electric break is adjusted to correspond to this position by one of the fine setting-screws attached to each of the five contact-pieces, which successively come into electric contact with a well-balanced tilt-hammer, which is itself adjustable. The apparatus being thus adjusted for the first thread, the others are, one by one, similarly adjusted.

Following are specimens of observations made with this instrument:

Observations for absolute personal equation.

Coast Survey Office, January 4, 1877.—C. A. S., observer.

	Set 1.			Set 2.			Set 3.			Set 4.			Set 5.		
	App.	Obs'r.	A.—O.	App.	Obs'r.	A.—O.	App.	Obs'r.	A.—O.	App.	Obs'r.	A.—O.	App.	Obs'r.	A.—O.
I	1.52	1.68	—0.16	0.22	0.34	—0.12	1.20	1.45	—0.25	0.30	0.40	—0.10	1.25	1.40	—0.15
II	5.35	5.42	.07	4.05	4.14	.09	5.02	5.10	.08	4.18	4.28	.10	4.98	5.18	.20
III	9.10	9.25	.15	7.84	7.85	.01	8.80	9.02	.22	7.86	7.90	.04	8.74	8.75	.01
IV	13.00	13.15	.15	11.75	11.92	.17	12.72	12.96	.24	11.66	11.92	.26	12.62	12.83	.21
V	17.50	17.68	—0.18	16.18	16.30	—0.12	17.20	17.47	—0.27	15.76	15.95	—0.19	17.08	17.35	—0.27
	Mean.......		—0.14	Mean.......		—0.10	Mean.......		—0.21	Mean.......		—0.14	Mean.......		—0.17

	Set 6.			Set 7.		
	App.	Obs'r.	A.—O.	App.	Obs'r.	A.—O.
I	0.31	0.40	—0.09	0.12	0.12	—0.00
II	4.20	4.12	+.08	3.96	4.10	.14
III	8.00	8.24	—.24	7.63	7.76	.13
IV	11.95	12.18	.23	11.50	11.64	.14
V	16.48	16.50	—0.02	16.05	16.12	—0.07
	Mean.......		—0.10			

RESULTING PERSONAL EQUATION.

From set 1	—0ˢ.14
2	.10
3	.21
4	.14
5	.17
6	.10
7	0.10
Mean	—0ˢ.14 ± 0ˢ.01

In these observations the chronometer breaks and the automatic register of the transits appear on an ordinary chronographic sheet. The same chronometer, through another circuit, breaks on the fillet of a Hipp chronograph where are also recorded the observer's breaks.

In reading off the chronograph sheet and fillet, the chronometer break preceding the first break of the apparatus or observer is taken to read zero. The absolute time is of no consequence, and this method secures small numbers. The columns headed "App." give the readings of the automatic breaks of the apparatus, and the columns headed "Obs'r" give the corresponding fillet-readings of the observer's breaks.

The personal equation—

$$A - O = - n$$

indicates the observer to be late of the apparatus by n seconds. Or since time of A is perfect for absolute measures, a negative indicates observer to be late or slow by that amount.

Observations similar to the above were made on the 3d and 5th of January. Below is a tabular statement of the results:

Observations for absolute personal equation.

Coast-Survey Office, January, 1877.—C. A. S., observer.

Number of set.	Observer late of apparatus.		
	January 3.	January 4.	January 5.
	s.	*s.*	*s.*
1	(*)	0. 14	0. 12
2	(*)	. 10	. 13
3	0. 09	. 21	. 15
4	. 13	. 14	. 15
5	. 17	. 17	. 15
6	. 20	. 10	. 18
7	....	0. 10	0. 20
	Mean, 0. 15 ± 0. 016	Mean, 0. 14 ± 0. 008	Mean, 0. 15 ± 0. 006

* Fillet failed.

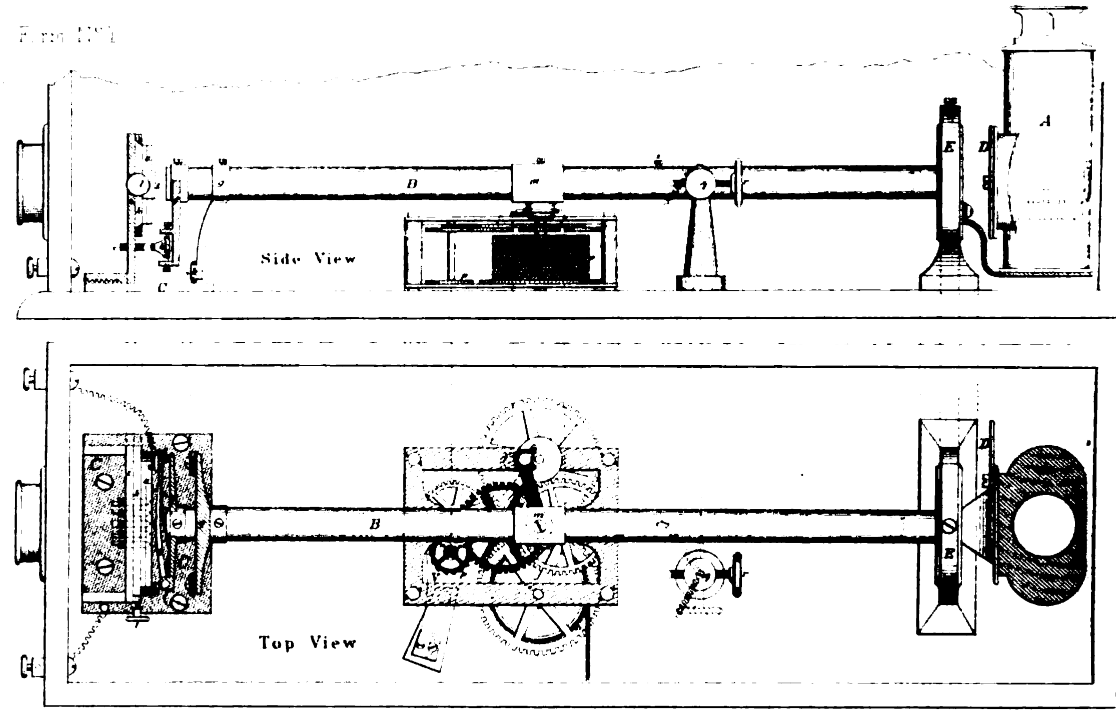
ABSTRACT OF PRECEDING OBSERVATIONS.

Date.	No. of sets observed.	Observer late of apparatus.	Probable error.
1877.		*s.*	
January 3	4	0. 15	± 0. 016
January 4..............	7	. 14	. 008
January 5..............	7	0. 15	± 0. 006
Mean	....	0. 147	± 0. 005

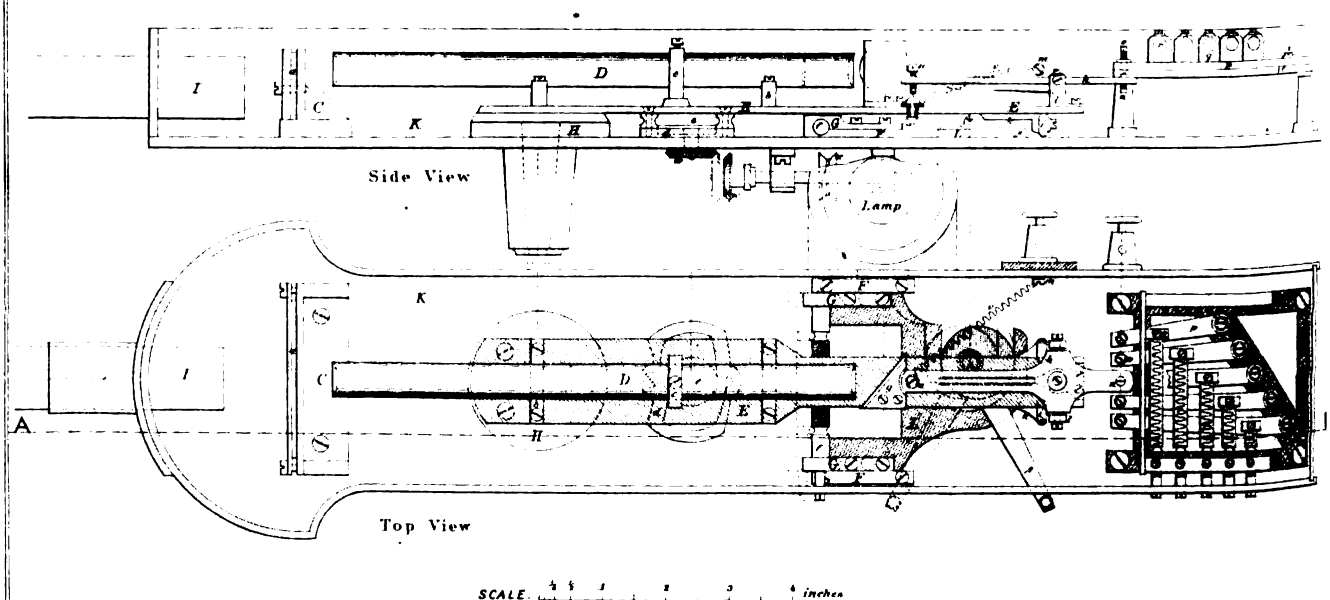
To exhibit more fully the working of the instrument under varied circumstances further observations, made by Messrs. F. Blake, jr., and H. W. Blair, are appended.

APPARATUS FOR DETERMINING PERSONAL EQUATION
IN OBSERVATIONS OF STAR TRANSITS.

Form Nº1.



Form Nº2.



Observations for absolute personal equation.

Coast-Survey Office, January, 1877.—F. B., jr., observer.

Number of set.	Observer late of apparatus.		
	January 9.	January 10.	January 11.
	s.	*s.*	*s.*
I	0. 15	0. 15	0. 13
II	. 13	. 14	. 14
III	. 12	. 12	. 15
IV	. 11	. 13	. 13
V	. 11	. 14	. 14
VI	. 11	. 15	. 12
VII	. 09	. 13	. 10
VIII	. 10	. 13	. 14
IX	. 10	. 13	. 12
X	0. 13	0. 16	0. 12
	0. 115 ± 0. 004	0. 138 ± 0. 003	0. 129 ± 0. 003

ABSTRACT OF PRECEDING OBSERVATIONS.

Date.	No. of sets observed.	Observer late of apparatus.	Probable error.
1877.		*s.*	*s.*
January 9.............	10	0. 115	±0. 004
January 10.............	10	. 138	. 003
January 11.............	10	0. 129	±0. 003
Mean	....	0. 127	±0. 002

Observations for absolute personal equation.

Coast-Survey Office, January, 1877.—H. W. B., observer.

Number of set.	Observer $\left\{ \begin{matrix} -\text{late} \\ +\text{early} \end{matrix} \right\}$ of apparatus.				
	January 23.	January 24.	January 25.	January 26.	January 29.
	s.	*s.*	*s.*	*s.*	*s.*
I	−0. 11	−0. 04	−0. 05	−0. 08	(†)
II	. 03	. 06	. 03	− . 08	−0. 07
III	. 05	. 02	− . 08	+ . 02	. 05
IV	− . 05	. 05	+ . 01	− . 08	. 07
V	+ . 01	(*)	− . 02	. 01	. 05
VI	−0. 05	(*)	. 04	− . 09	. 06
VII	....	. 05	. 02	+ . 03	. 03
VIII	....	. 10	. 07	− . 09	. 04
IX	....	. 08	. 09	. 02	. 05
X	....	. 10	−0. 05	−0. 09	−0. 09
XI	....	. 12	....	....	....
XII	....	−0. 11	....	....	....
	−0. 047 ± 0. 007	−0. 073 ± 0. 006	−0. 044 ± 0. 005	−0. 049 ± 0. 010	−0. 057 ± 0. 003

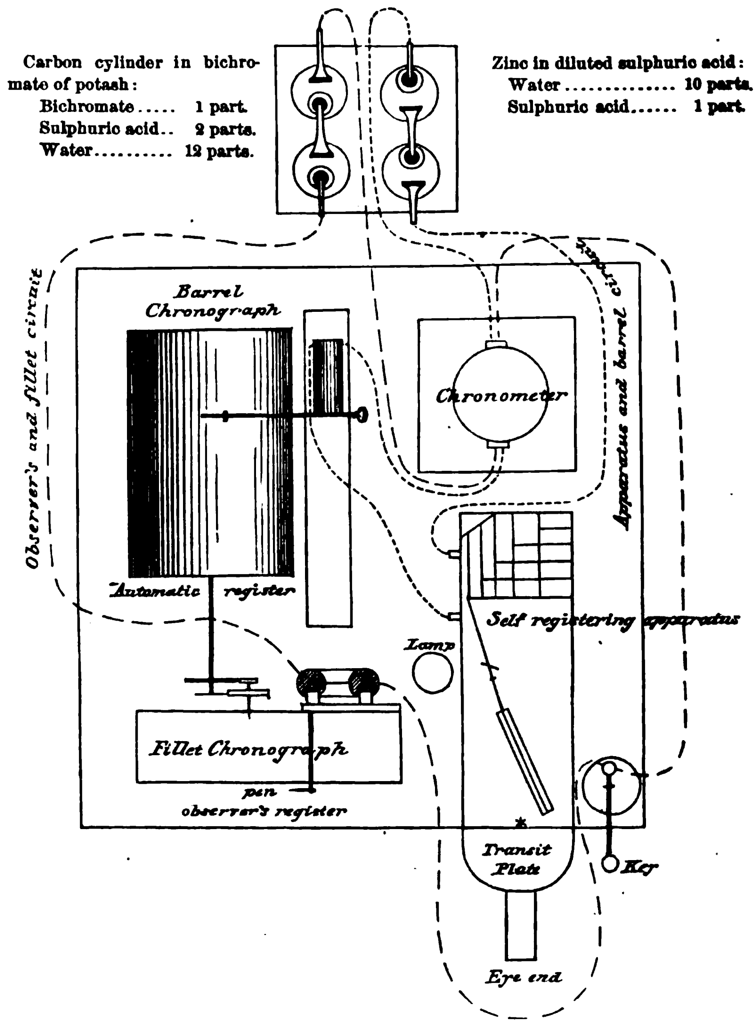
* Fillet failed. † Chronograph sheet failed.

ABSTRACT OF PRECEDING OBSERVATIONS.

Date.	No. of sets observed.	Observer late of apparatus.	Probable error.
1877.		s.	s.
January 23	6	0.047	±0.007
January 24	10	.073	.006
January 25	10	.044	.005
January 26	10	.049	.010
January 29	9	0.057	±0.003
	45		
Mean		0.054	±0.003

A careful scrutiny of the above observations shows that the precision of the instrument is quite satisfactory, and that the variations in the single results are to be ascribed to actual errors of observation. It would have been desirable to make the construction such that the transits in either direction could be observed consecutively, but the necessary breadth of the non-conducting lines requires that the adjustment of the star-breaks be made of either their right or left hand edges. The apparent direction of the transit is, however, readily changed by the use of an inverting eye-piece.

Bichromate of potash battery (four cups).



The above diagram shows the general arrangement of the various parts of the apparatus upon an observing-table, the electric connections, and the battery, which have been found convenient in use.

APPENDIX No. 18.

TRANSATLANTIC LONGITUDES.

FINAL REPORT ON THE DETERMINATION OF 1872, WITH A REVIEW OF PREVIOUS DETERMINATIONS.

BY J. E. HILGARD, ASSISTANT.

PART I.

The determination of the exact longitude of some point in the triangulation of the Coast Survey, with reference to the principal observatories of Europe, is one of the most important problems of the work; and the various means known to science have been successively brought to bear on its solution.

The Coast Survey Reports from 1844 to 1866 show that the methods of moon-culminations, of chronometer-transportation, and of lunar occultations have each in turn received a large share of attention. The latter method, however, has not yet yielded the full results that may be expected of it in consequence of the infrequency with which corresponding observations have been obtained in Europe and America; but it cannot be doubted that, with a suitably-organized system of observation, the method will eventually give results of great value.

Upon the successful completion of the Atlantic telegraph-cable from Ireland to Newfoundland, measures were at once taken to make use of it for the determination of the longitude difference between the two countries by the "American method" of telegraphic time-signals. This method was conceived by Mr. Sears C. Walker, of the Coast Survey, and first practiced by him on the night of October 10, 1846, when time-signals were successfully exchanged over a telegraph-line which united the Observatory at Washington and the Central High School Observatory at Philadelphia. Mr. Walker's account of this work is published in the Coast Survey Report for 1846, Appendix No. 11.

The results of the operations between Ireland and Newfoundland, conducted by Dr. B. A. Gould, have been given at length in the Report for 1867. Although the longitude value thus obtained was far more nearly certain than that of any previous determination, there was still left a larger margin of doubt as to its precision than is desirable in a fundamental determination. This uncertainty, which probably does not exceed a quarter second of time, is due to the fact that there was no determination of the personal equation difference between Mr. Dunkin, the Greenwich "standard observer," and Mr. Boutelle, the Coast Survey observer at Calais; and that while we can measure the total time of transmission of signals through the cable and back again, we are unable to separate the duration in opposite directions, and are obliged to assume it to be equal—an assumption which may not be exact within a sensible fraction of a second.

When the laying of the French cable from Brest, France, to Duxbury, Mass., afforded an independent means of verifying the former result by observations under entirely different conditions, the opportunity was promptly seized, and the longitude between Brest and Duxbury determined by Mr. G. W. Dean, assistant in the Coast Survey, as set forth in the Report for 1870.

At that time, however, no cable was in operation between Brest and England; so Mr. Dean was unable to carry his determination direct to the observatory at Greenwich. Such a cable having been subsequently laid, the wanting link in the chain of longitude was supplied during the summer of 1872 by the writer, who had temporarily given up the charge of the Coast Survey Office at Washington in order to bring this much-desired operation to a satisfactory conclusion. While re-occupying Brest for that purpose, it was thought best that the experiments through the French cable should be repeated, with the addition of an intermediate station at St. Pierre, where the long cable makes a landing; and Assistant George W. Dean was placed in charge of the operations on the American side.

The general plan of the work was to unite at Brest time-signals from St. Pierre, from Greenwich, and from Paris, sent at nearly the same time and compared by means of the Brest chrono-

graph; and to determine the personal equations of the several observers through one of them, who should observe successively with all the rest. This was done by Mr. Francis Blake, jr., sub-assistant in the Coast Survey, by whom the writer was ably assisted throughout the work. Through the kindness and assistance of Sir George B. Airy, the astronomer royal of England, and of Mr. Delaunay, the distinguished director of the Paris observatory, whose lamented death occurred while the operations were in progress, and through the generous courtesy of the French Atlantic Telegraph Company, and of the Submarine Telegraph Company, the work was brought to a successful conclusion during the month of September, 1872.

In the course of these operations the longitude between Paris and Greenwich was determined incidentally in two different ways; first, in July, via Brest, and afterward in September, between Greenwich and Paris direct, through the submarine cable via Calais. The two determinations were not entirely independent of each other, since the personal-equation difference between Mr. Blake and the Paris observer enters into both; but the near satisfaction of the equation—

Brest — Paris + Paris — Greenwich + Greenwich — Brest = 0,

or the closing of that "longitude triangle," must entitle the results obtained to great confidence.

Before reciting the principal results a brief description will be given of the stations occupied and the instruments used during the work.

SECTION I.

CAMBRIDGE.

The Coast Survey station at Cambridge was within the grounds of the Harvard College Observatory, 108 feet—or $0^s.096$ of time—west of the center of the great equatorial dome of the main building, to which point our longitudes are usually referred. From the center of the meridian circle in the west wing it was 73 feet 5 inches west and 39 feet north. The station is marked by the two transit-piers which stand in an east and west line. They are of granite, dressed to 9 inches square at the tops, and so placed as to be 3 feet above ground, and their outside edges 2 feet 9 inches apart. They weigh about a ton each.

The longitude observations at this station were made by Mr. Edwin Smith, of the Coast Survey, who used the following instruments:

C. S. Transit No. 5, made by Messrs. Troughton and Simms, of London, and provided with a reversing apparatus by Mr. William Wurdemann, chief mechanician of the Coast Survey at Washington. This instrument, which was mounted upon the granite piers before mentioned, has an object-glass 2.75 inches in diameter and 46 inches in focal length; and a diagonal eye-piece of which the magnifying power is about ninety. A new glass diaphragm made by Prof. William A. Rogers, assistant Harvard College Observatory, was substituted for the usual system of spider-lines. This diaphragm is of very thin plate-glass, upon which are ruled twenty-five double lines in groups of five lines each. Stars are observed when midway between these double lines, which are about two tenths of a second of time apart.

For convenience in recording, each group is designated by a letter and each line by a number. This notation will be readily understood by a reference to the accompanying diagram, (Fig. 1), which shows the order in which a star crosses the lines at upper culmination when the perforated end of the transit axis is to the westward. This position of the transit-instrument is denoted in the record by "Lamp west." For the reversed position, on "Lamp east," the star crosses the lines in the inverse order.

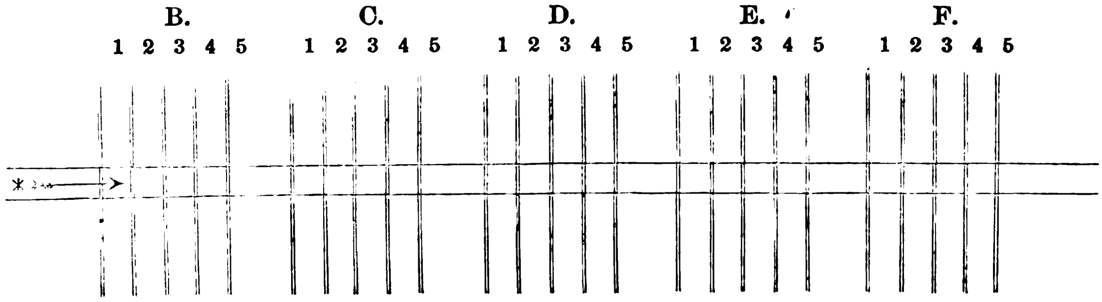


FIG. 1.

There is also a micrometer-thread, which was used in determining the flexure of the transit-instrument. The observations for this purpose are described in Section XIII of this report.

The striding-level used has been attached to the instrument for many years. It is marked "A1;" and the value of one division of its scale, as determined with the meridian circle of the observatory during the season's work, is 1.02 seconds of arc, or 0.068 seconds of time.

The transit-observations and longitude-signals were generally recorded upon a "Bond spring-governor register," which belongs to the observatory, and is there known as the "north chronograph;" but occasional use was made of the "west chronograph," a similar instrument, mounted in the west wing near the meridian circle, with which it is ordinarily used. These chronographs were made by Messrs. William Bond & Sons, of Boston, and are similar to the one fully described in the Annals of the Astronomical Observatory of Harvard College. (Vol. I, Part I, page xlix.)

The standard sidereal or "south clock" of the observatory was used throughout the work. This clock was made by Frodsham, of London, and is provided with a break-circuit attachment by which each second of time is recorded upon the chronograph excepting the zero-second at beginning of every minute, which is omitted.

SECTION II.

ST. PIERRE.

The observations at St. Pierre were made by Mr. Edward Goodfellow, assistant United States Coast Survey, aided by Mr. A. H. Scott.

St. Pierre Island is the most southern and eastern of the three islands composing the Miquelon group, off the south coast of Newfoundland, and just to the westward of the entrance to Placentia Bay. It is about five miles long and from a mile to two miles wide, and consists mainly of a series of rocky ridges, rising abruptly from the sea, with a narrow plateau at their southern base upon which the town of St. Pierre is built.

By permission of the governor of St. Pierre, a site for the temporary observatory was selected just outside the town limits, and within a convenient distance from the French cable office. By measurements upon the French Admiralty Chart No. 303, the station is 2,121.95 meters (1′ 8″.7) north and 1,331.42 meters (1′ 2″.8) west of Galantry Head Light, the approximate position of which is—

Latitude, 46° 46′ 3″ north;
Longitude, 56° 9′ 2″ west of Greenwich.

After the departure of the Coast Survey party from St. Pierre, Commander W. F. Maxwell, R. N., observed for latitude at the pier which marks the longitude-station. Under date of St. John's, N. F., December 9, 1872, he communicated the results of his observations to Mr. Goodfellow as follows:

"The latitude of your observatory I found to be 46° 46′ 51″.2 N., the mean of a number of observations of Polaris on the north and ϵ Pegasi and β Aquarii on the south."

The figures 46° 46′ 51″ N. have accordingly been adopted for the latitude of the Coast Survey longitude station at St. Pierre.

To mark the station-point after the longitude-observations were finished, a granite slab, 36 by 30 inches in cross-section and 7 inches thick, was set in the ground as a foundation-stone for a granite pier. The top of the slab is 14 inches below the surface, and in its center is a copper bolt marking, below the surface, the position of transit center.

This slab having been well secured in its position, a granite pier was placed upon it in an excavation made for the purpose on its upper surface. This pier is 21 by 15 inches in cross-section and 49 inches long, dressed smooth for a distance of 38 inches from the top. In a drill-hole at center of top is inserted a copper bolt $\frac{3}{4}$ of an inch in diameter and 3 inches long. The intersection of two cross-lines cut upon this bolt marks the center of transit-instrument, the point of reference for latitude and longitude.

The pier projects 35 inches above the surface of the ground, and has on its top the inscription:

U. S. C. S.
1872.

A strong wooden fence, 7 feet square, was built around it, and assurances were obtained from the government of the island that the inclosure should be carefully guarded from molestation.

The Coast Survey Transit No. 6 was used at this station. In size and construction it is precisely similar to Transit No. 5, already described in Section I. It was mounted upon two blocks of seasoned oak, 6 feet long and 10 by 12 inches in cross-section. These blocks were secured firmly to each other, at the proper distance, by strong planking, for a length of 2 feet from the base, so as to make a very solid foundation for the instrument when the whole structure was set upright, with its base 33 inches below the surface of the ground, and the space between and around the blocks filled with sand and gravel, well rammed down.

The value of one division of striding-level marked "B" is 0″.86 of arc.

The reticule consists of twenty-five spider-lines, arranged in groups, or "tallies," of five lines each at equatorial intervals of about two and a half seconds of time.

Fig. 2 shows the system of notation and the order in which a star crosses the lines at upper culmination, lamp west.

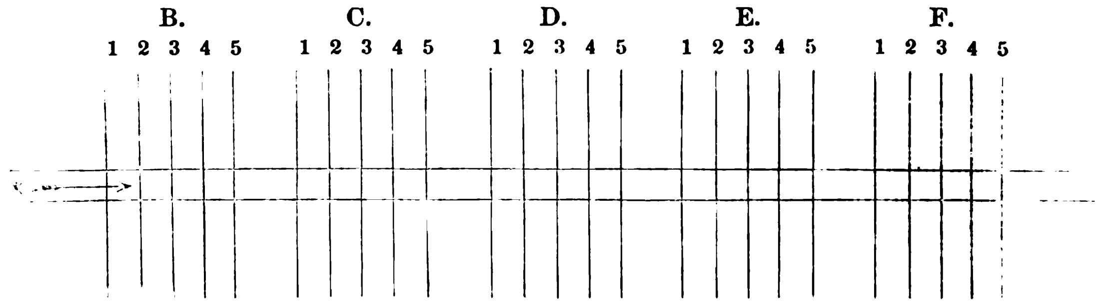


FIG. 2.

There is also a micrometer-thread which was used in making the observations for flexure of transit-instrument. These observations were made at Cambridge in connection with the observations for personal equations, and are described in Section XIII.

The transit-observations and longitude-signals were recorded upon a Bond "spring governor" chronograph similar to the one used at Cambridge. This chronograph was graduated by Frodsham break-circuit chronometer No. 3462 up to July 6, when, owing to a defect in the working of its break-circuit apparatus, No. 3451, by the same maker, was substituted for it.

For the loan of this chronometer, as well as for the loan of the chronograph, the Coast Survey was indebted to Prof. Joseph Winlock, director of the Harvard College Observatory.

In observing for time, the standard-clock stars of the American Ephemeris were preferred; but any long intervals in that list were filled with stars from the Pulkowa List of 1869.

Mr. Goodfellow is specially indebted to the Hon. M. M. Jackson, United States consul at Halifax, for his kindness in obtaining permission for the transportation of the Coast Survey party to St. Pierre by one of the steamers of the Quebec and Gulf Ports Steamship Company.

M. l'Heureux, commandant of the islands of St. Pierre and Miquelon, extended every facility for the establishment of the observatory and many personal courtesies to the officers of the party.

To Mr. Gott, manager of the St. Pierre office of the French Transatlantic Cable Company, and to Mr. Ward, his successor, thanks are due for the promptness and friendly co-operation with which the arrangements for cable-exchanges were made. The same acknowledgments are due to Mr. A. M. Mackay, superintendent of the New York, Newfoundland, and London Telegraph Company, at St. John's, N. F., and to Mr. Stephenson, chief operator, and Mr. Earle, his assistant, at St. Pierre.

After the longitude-work was finished, through the kindness of Admiral Surville, commandant-in-chief of the fleet of the Antilles, the Coast Survey instruments were taken to New York on board his flag-ship, the "*Minerve.*"

SECTION III.

BREST.

The Coast Survey station at Brest was on the Place du Champs de Bataille, in front of the buildings on the Rue St. Yves, occupied by the Transatlantic Telegraph Company and the Government Telegraph of France. A loop of insulated copper wire connected it with the cable testing-room and the government office. It was found to be 8.46 seconds of arc south and 0.44 seconds of time east of the tower of St. Louis Church, a point in the trigonometrical survey of France.

The temporary building erected for an observatory was 13 feet long, 8 feet wide, and 9 feet high. It was divided into two compartments by a transverse partition set 4 feet from the western end.

In the larger compartment C. S. Transit No. 4 was mounted upon the granite piers used by Mr. Dean in 1869–'70, they having been brought from the site of his observatory within the grounds of the Establishment des Pupilles de la Marine. This instrument, which has been used in the service for more than twenty years, was made in London, by Messrs. Troughton & Simms, and is similar in size and construction to the ones already mentioned as having been used at Cambridge and St. Pierre. It has a clear aperture of 2.75 inches, a focal length of 45 inches, and a transit axis of 25 inches. It is provided with a reversing apparatus, by which the position of the perforated pivot can be changed in less than half a minute; a striding-level with scale, one division of which is equal to 0.945 seconds of arc; a diagonal eye-piece of a power of about ninety-five; and two illuminating lamps placed on small shelves unconnected with the instrument.

The old system of twenty-five spider-lines, in groups of five each, was removed, and in its place was substituted a Rogers glass diaphragm. This diaphragm is of very thin plate-glass, upon which, in the space of thirty-four hundredths of an inch, are ruled seven groups, or "tallies," of three double lines each, the distance between the double lines being about twelve hundredths of a second of time at the equator. The tallies are denoted by the letters A to G, inclusive, and the individual lines by figures 1, 2, and 3. This notation begins at the perforated, or "lamp," end of the transit axis, so that when the field is illuminated by the western lamp, the position of the instrument designated in the record by "lamp west," a star at upper culmination crosses the lines as shown in Fig. 3.

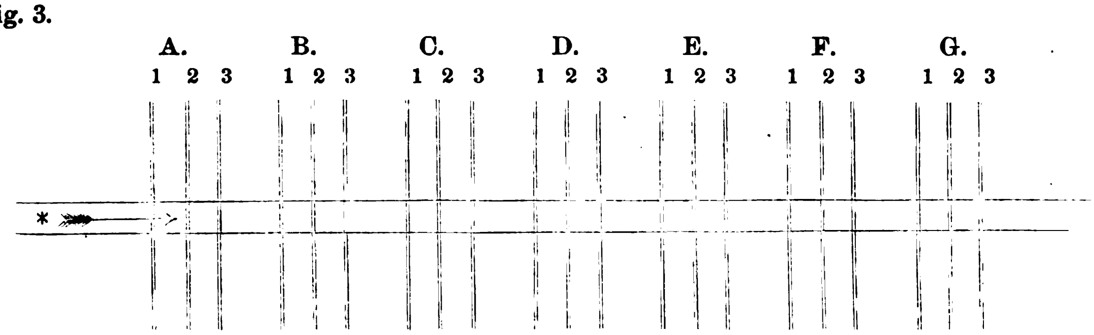


FIG. 3.

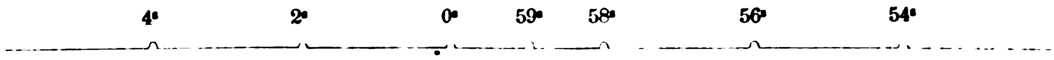
A star is recorded when midway between the double lines, and generally only the tallies B, C, D, E, F are used.

The field is illuminated by light which enters the axis at lamp-end, and is reflected down the tube by an open metallic ring. Stars of less than the sixth magnitude cannot be satisfactorily observed.

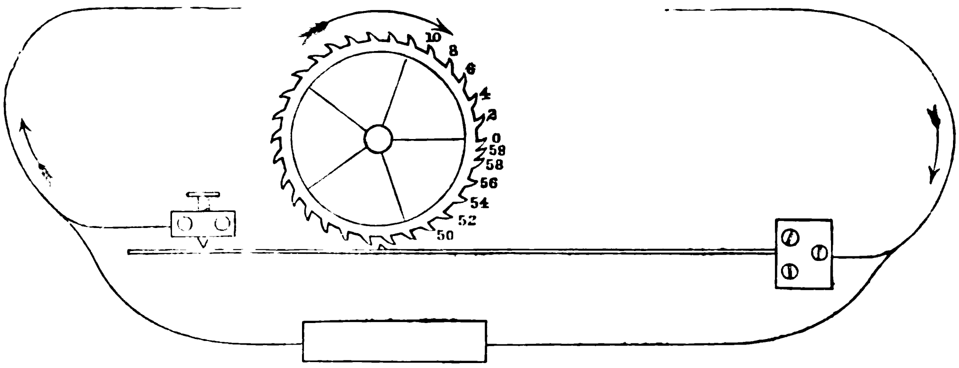
The Coast Survey chronograph, "spring-governor No. 2," made by Messrs. William Bond & Sons, of Boston, was placed in the smaller compartment of the observatory, in order that its noise while running might not influence the transit-observer. It is similar to the chronographs used at Cambridge and St. Pierre, being provided with a single pen, which describes a continuous spiral upon a sheet of paper attached to a revolving drum, and records by offsets the chronometer breaks and observer's signals.

The chronograph was graduated by circuit-breaking chronometer "William Bond & Sons, No.

380," which was placed in a dry cellar beneath the building occupied by the cable company, and connected with the observatory by a loop of insulated copper wire. Maximum and minimum thermometers showed that during the work the temperature of this cellar ranged only from $14^{\circ}.5$ to $17^{\circ}.0$ centigrade. The circuit-breaking apparatus of this chronometer consists of an extra wheel, attached to the seconds' arbor, the circumference of which is divided into thirty equidistant teeth, with a thirty first tooth inserted between the teeth which mark the fifty-eighth and the zero second. The electric circuit is closed by a delicate gold spring secured at one end and resting against an adjustable screw at the other. This spring is so placed that in passing it each tooth of the extra wheel just described strikes a jewel set in its face, lifting it from the screw and recording a break upon the chronograph. Thus the chronographic record of the chronometer before and after the beginning of a minute will read—



The circuit-breaking apparatus just described is graphically represented in the accompanying sketch (Fig. 4):



To avoid the inconvenience arising from the deflagration of contact surfaces by the spark developed at the break, a branch circuit including a resistance coil is introduced, according to the writer's device, bridging the break and permitting the ready passage of the secondary current, while the resistance is too great to allow the recording-magnet of the chronograph to be sensibly affected.

It will be observed that the rate of this chronometer was not only determined by the observations made at Brest, but was also checked by daily comparisons with the clocks at Paris and Greenwich. Its performance was very satisfactory.

The local battery used in the observatory consisted at first of three elements of Callot's modification of Daniell's sulphate of copper battery; but on July 9 a battery of six Menotti elements was substituted for it.

A small and very delicate recording-key—made for the observer—was used at the transit instrument.

Only stars from the American Ephemeris were observed at Brest, and it was the aim of the observer to obtain each night a full set consisting of five time-stars and two circumpolars—one above and one below the pole—in each position of the instrument. By this system it is practicable to deduce the azimuthal deviation of the instrument independently for either position, and even to arrive at a fair value of the collimation when observations have been obtained in but one position. Whenever the weather permitted, a second set was observed immediately after the exchange of longitude-signals.

The mayor of Brest, Mr. A. Penquer, afforded facilities for establishing and protecting the station on the public square; Mr. G. Amyot, chief inspector of telegraphs in the department of Finisterre, superintended the construction of the necessary telegraph-lines; Mr. Sureau, manager of the gov-

ernment office, exerted himself to make the work with Paris successful; and Mr. C. F. Varley, chief electrician of the French Cable Company, gave most valuable suggestions and advice in regard to the manipulation of the cable, the free use of which, for longitude purposes, was obtained through the courtesy of Capt. R. C. Mayne, R. N., C. B., managing director; Mr. Cummings, secretary; and Mr. Halsey and Baron Reuter, directors.

The peculiarly valuable services of Mr. Thomas Andrews, manager of the Brest office, are elsewhere acknowledged. Messrs. Bécue, Betts, Crilly, Deschamps, Kelly, and Webster, members of the cable-staff, were at all times—under direction of Mr. Andrews—assiduous in their exertions in behalf of the work. Mr. Boudro, of the government office, aided in the exchange of time-signals with Paris, and Mr. Le Moyne was a faithful assistant to the party throughout the work.

SECTION IV.

PARIS.

The work at the Paris observatory was carried on under the supervision of Mr. Loewy, who cordially co-operated with the writer throughout the longitude determinations. The chronographic method of recording transit-observations, not then in ordinary use at the observatory, was adopted for the present occasion, and the assistant astronomer, Mr. L. F. Folain, who made all the corresponding observations, devoted a fortnight to preliminary practice with the new method, so as to obtain a settled habit of observing. The large transit-instrument of the observatory, "*la lunette méridienne*," was employed in the work, which was prosecuted with the greatest assiduity. The instrument was reversed twice on each night, and two complete sets of observations were made, each set comprising eight stars in each position of the instrument, beside circumpolars and micrometer readings on the meridian mark.

La lunette méridienne at Paris is $0^s.12$ east of the meridian of France, from which all longitudes are reckoned.

GREENWICH.

At Greenwich the regular routine of observing was followed, as described in the Greenwich Observations. The transit-circle observers change in a certain rotation, two observers generally determining the clock-correction each day, their observations being referred to a common standard by the application of the personal-equation differences derived from the comparisons thus obtained.

The transit-circle is mounted in the meridian of Greenwich, from which all longitudes are reckoned.

The Coast Survey party are specially indebted to Mr. William Ellis, assistant in the astronomical department of the observatory, who, under the direction of the astronomer royal, aided them in every way in the prosecution of the longitude-work.

The free use of the Submarine Cable was cheerfully granted by Mr. Stephen McD. Clare, secretary of the company, while Mr. H. C. Fischer, manager of the London Central Station, arranged the telegraphic circuit from Greenwich to Paris, and assigned to the party one of his most faithful and accomplished telegraphists, Mr. W. G. Gould, whose devotion to the work deserves special mention.

A description of the instruments and methods of observing at each of the longitude-stations having been given, the interchange of time-signals, and the longitude results deduced therefrom, will now be considered.

SECTION V.

CAMBRIDGE—ST. PIERRE.

It was intended that the observations at, and the exchanges of time-signals between, the American stations should be as nearly simultaneous with those in Europe as the weather might allow, in order that the intermediate stations at Brest and St. Pierre should sensibly disappear from the determination of the longitude of Cambridge from Greenwich and Paris.

Such simultaneous operations proved to be impracticable, in consequence of the condition of the cables. The long cable between Brest and St. Pierre was working badly and had to be repaired before it was fit for our use. When this was accomplished, it proved to have a better insulation than ever before, and signals were transmitted with great sharpness; but, mean time, the cable between St. Pierre and Duxbury had been broken, and could not be repaired during the summer, so our arrangements were necessarily changed.

Mr. Dean, who had charge of the American part of the operations, at once proceeded to make arrangements for exchanging time-signals between St. Pierre and Cambridge, via the short cable, from St. Pierre to Sydney, 209 miles; thence by the land-lines, Sydney to Pictou, 214 miles; and Pictou to Cambridge, 666 miles; in all, a through circuit of 1,089 miles, with repeaters at Sydney, St. John, N. B., and Boston. This part of the work offers no unusual features, as clock-signals were exchanged and automatically registered on the chronographs by the methods ordinarily made use of in the longitude determinations of the Coast Survey. Time-signals were exchanged on seven nights; but the determinations of the clock and instrumental corrections at Cambridge on July 21 and 23 were so extremely weak that the longitude results on those dates, although accordant, cannot be allowed to influence the final result. The longitude differences, deduced from five nights when good observations were obtained at each station, were as follows:

Cambridge and St. Pierre, 1872.

	m. s.
July 28	59 48.738
29	48.749
August 1	48.833
6	48.637
9	59 48.805
	s.
Mean observed difference of longitude	59 48.752 ± 0.023
Personal equation, Goodfellow-Smith	—0.057 ± 0.011
Difference of longitude	59 48.695 ± 0.025

SECTION VI.

ST. PIERRE—BREST.

The signals sent through the Brest-St. Pierre cable were observed by means of the "Thomson Galvanometer," the construction of which is based upon the ingenious device of Sir William Thomson, in applying to a delicate galvanometer the principle of reflection used by Gauss for heavy magnets. A similar instrument, used in the 1866 longitude determinations by Dr. B. A. Gould, is described by him as follows in his report on that work, published in the Coast Survey Report of 1867:

"A small mirror, to the back of which is attached a permanent magnet, the joint weight of the two being from five to six centigrams, is held by a single fiber above and below, in the center of a coil of fine wire which forms part of the galvanic circuit, and its position and sensitiveness are regulated by movable bar-magnets placed in the immediate vicinity. Upon the mirror is thrown a beam of light through a slit in front of a bright kerosene-lamp, and the deflections of the needle are noted by the movements of the reflected beam, which is received upon a strip of white paper. The exquisite delicacy of this galvanometer, as well as the electrical excellence of the telegraph-cables, may readily be appreciated after the beautiful experiment in which the electricians at Valencia and Newfoundland conversed with each other on a circuit not far from 700 myriameters (4,320 statute miles) in length, formed of the two cables joined at the ends, using a battery composed of a percussion gun-cap, a morsel of zinc, and a drop of acidulated water."

Before leaving Washington, the writer had devised and attended to the construction of a key, by which a chronographic record of signals sent into the cable could be obtained. This key is similar to the ordinary cable-key devised by Sir William Thomson, with an attachment by which the

local circuit may be passed through it in such a manner as to be broken at the instant the cable-circuit is closed by the depression of either spring. It is also susceptible of an adjustment by which an exact record can be obtained of the time during which the cable-circuit is closed. It is evident, therefore, that all time-signals sent into the cable were accurately recorded upon the chronograph.

In receiving time-signals from St. Pierre, the observer at Brest, watching the "spot," or beam of light reflected from the galvanometer, pressed his local break-circuit key at the instant he saw it dart to the right or left of scale-center. It is obvious that the chronographic record in this case must be too late by a certain interval of time depending upon the observer's personal error in noting the signals; but it will be seen that this personal error was accurately measured and entirely eliminated from the longitude result.

In any case, the result would be affected by only half the difference between the personal errors at Brest and St. Pierre; and experience has shown that between most observers this difference is very small.

On Tuesday, July 9, a preliminary exchange of time-signals was effected between Brest and St. Pierre. St. Pierre first sent five-second charges—positive and negative—for two minutes. Brest found that at end of each five seconds the cable had so nearly discharged itself that the moment of raising key at St. Pierre was not marked by any apparent impulse to the spot. St. Pierre then sent a number of two-second charges, but the discharge attending the raising of his key was not sharply enough defined to admit of accurate noting, and Brest had no confidence in the times recorded on his chronograph. Brest then sent similar signals to St. Pierre, who complained of difficulty in distinguishing beginning of discharge.

Brest next requested St. Pierre to send a set of signals consisting of alternate positive and negative taps every fifth second for two minutes. He did so, and a very satisfactory record of the times at which spot darted to right or left of scale-center was obtained.

Brest then sent a similar set to St. Pierre, who remarked that the signals were sharp and easy to note. Two more similar sets sent either way finished the night's work. At Brest, these preliminary exchanges were carried on in the operating-room of the cable-office, with the instruments in daily use by the company (excepting the cable-key already described) no special attention being given to resistance of galvanometer, throw of spot, or strength of battery.

On July 12 the exchanges were made under the same conditions.

The success of our cable-work on subsequent nights of exchange was due in no small degree to the kind exertions of Mr. Thomas Andrews, superintendent at Brest, who personally attended to the management of the cable-instruments in our observatory, and by directions to the superintendent at St. Pierre secured a similar arrangement for the Coast Survey observer at that station.

Both stations worked directly into cable with batteries of ten Menotti cells, and received through condensers of the same capacity (47 microfarads) and galvanometers of the same resistance (3,000 ohms) and the same magnetic moment. The galvanometer mirrors were suspended by silk fiber in clock-oil.

On July 13 communication was established between the Brest observatory and the observatory at St. Pierre. During the exchange of a few preliminary signals each observer adjusted his galvanometer so as to have the spot thrown exactly 150 divisions (about four inches) to right or left of zero of scale, which was about thirty-two inches from galvanometer. Immediately thereafter although it was raining at both stations, signals were exchanged in accordance with the following programme, which the experiments of July 9 and 12 had proved to be best suited to our wants:

PROGRAMME FOR CABLE-EXCHANGES.

At one a. m., Greenwich time, Brest gives three warning rattles, followed by positive tap at beginning of minute; negative at five seconds; positive at ten seconds; and so on until twenty-five signals have been sent. Then, after ten seconds' interval, gives three terminal rattles.

St. Pierre records warning and terminal rattles upon his chronograph, and the instants at which spot darts to right or left during intermediate signals. This forms a "set." St. Pierre then sends Brest a set; Brest one to St. Pierre; and so on until three sets have been sent and received at each station. Cable-work for the night is then finished.

It will be well to have signals (both sent and received) recorded by single breaks upon chronograph, as we shall in no instance be called upon to note the discharge of cable.

Good observations were obtained at both stations, and time-signals exchanged in accordance with the above programme on five nights, and the results for longitude deduced therefrom are as follows:

St. Pierre and Brest, 1872.

	h. m. s.
July 14	3 26 45.272
17	45.292
18	45.162
21	45.327
23	3 26 45.263

The results for longitude deduced from the preliminary exchange of July 9 and 12 are as follows:

	h. m. s.
July 9	3 26 45.040
12	3 26 45.071

But, as has already been stated, no special attention was given on these dates to the resistance of galvanometer, throw of spot, or strength of battery. These results, therefore, cannot fairly be allowed to influence the final longitude value with full weight. After careful consideration it has been decided to assign half weight to them, and to combine them with the results obtained on the other five dates, as follows:

St. Pierre and Brest, 1872.

	Weight	h. m. s.	s.
July 9	Weight, 0.5	3 26 45.040	
12	0.5	45.071	
14	1.0	45.272	
17	1.0	45.292	
18	1.0	45.162	
21	1.0	45.327	
23	1.0	3 26 45.263	
Mean observed difference of longitude		3 26 45.229	± 0.025
Personal equation, Goodfellow–Blake		+ 0.015	± 0.009
One-half difference personal error in noting cable-signals		+ 0.010	± 0.002
Difference of longitude		3 26 45.254	± 0.027

SECTION VII.

PERSONAL ERRORS IN NOTING CABLE TIME-SIGNALS.

Under this heading are included not only the actual personal errors of the observers in noting the signals, as indicated by the deflections of the cable-galvanometers, but also the armature-times of the galvanometers themselves. The reasons for thus combining these personal errors and armature-times are that they both have similar effects on the results for longitude and wave-time, and that, combined, they were readily subjected to direct measurement of great nicety; while, to arrive at a determination of each separately, would have involved experiments for making which no suitable instruments were at hand. Furthermore, a separate determination would not have added to the accuracy of the work in any particular.

In this connection it should be noted that the term "armature-time," as applied to a cable-galvanometer, is used for convenience to designate the interval of time it takes for the magnet of the galvanometer, with its attached mirror, to be moved through an arc sufficiently large to cause

a sensible deflection of the reflected spot of light. Also, that the term "personal error in noting cable-signals" is always to be understood as including this armature-time.

The arrangements at Brest for determining the personal error of Mr. Blake in noting the time-signals received from St. Pierre were as follows:

The governing apparatus of the chronograph was removed so as to allow the drum to revolve at its maximum speed.

The galvanometer was taken from the observatory to testing-room of cable-office and connected in a "local-main" circuit with one Menotti cell and the observatory cable-key, and to make the signals sent with this key similar to those received from St. Pierre during cable-work, a shunt of 604.6 units power, and 5,162 units of resistance cribs were introduced into the circuit. Signals were then sent from the observatory by an assistant, at intervals of five seconds, and recorded upon the chronograph by Mr. Blake, with the same chronograph-key used by him in receiving the regular cable-signals from St. Pierre. The local circuit connecting this key with the chronograph was passed through the local connections of the cable-key at the observatory in such a way as to be broken at the instant a fictitious cable-signal was sent into the "local-main" circuit by the assistant. It is obvious that of each signal with the cable-key there are two records upon the chronograph, and that the difference between them is an exact measure of the observer's personal error in noting.

Three sets of observations were made at Brest with the following results:

Date.	Mean solar time.	Number of signals.	Personal error.
1872.	h. m.		s.
July 24	4 30 p. m..	44	0. 244
24	10 0 p. m..	44	0. 230
25	4 0 p. m..	44	0. 239
Mean personal error of Blake			0. 238 ± 0. 004

At St. Pierre similar arrangements were made by Mr. Goodfellow, who determined his absolute personal error in noting signals on July 26, 27, 29, and 30. The final value deduced from 1,090 signals noted by him is—

	s. s.
Mean personal error of Goodfellow	0. 259 ± 0. 002
Personal error of Blake	0. 238 ± 0. 004
Personal error of Goodfellow	0. 259 ± 0. 002
Sum	0. 497 ± 0. 004
Difference	0. 021 ± 0. 004
One-half difference	0. 010 ± 0. 002

SECTION VIII.

WAVE-TIME OF CABLE-SIGNALS.

No special observations were made for the purpose of determining the velocity of transmission, or "wave-time," of signals through the cable; but the results therefor incidentally deduced from the time signals exchanged for longitude are entitled to great weight, since the arrangements at each station (page 171) were such as to insure, as nearly as possible, the same velocity for signals sent from east to west and *vice versa*.

In cable-work, as is well known, the difference between the longitudes resulting from time-signals sent in each direction is equal to the sum of the actual wave-times of the signals themselves, plus the sum of the armature-times of the galvanometers, plus the sum of any personal errors in noting the signals as indicated by the deflections of the galvanometers.

A consideration of the arrangements for exchanging cable time-signals, as described in Section VI, shows that the armature-times of the recording chronographs, whether equal or unequal, could have no effect on their apparent or actual wave-times.

The excess of west-east over east-west longitudes, as deduced from twenty-two sets of cable time-signals exchanged on seven nights, is given in the following table:

Wave-time of cable-signals.

Date.	Set.	Number of signals in set. Brest to St. Pierre.	Number of signals in set. St. Pierre to Brest.	Difference between longitude Brest — St. Pierre and St. Pierre — Brest.	Daily mean.
1872.				s.	s.
July 9	I	17	16	1.266	
9	II	23	25	1.232	1.249
12	I	25	23	1.237	
12	II	25	22	1.204	
12	III	24	23	1.200	1.214
14	I	24	25	1.237	
14	II	25	25	1.199	
14	III	23	24	1.220	
14	IV	25	7	1.242	1.224
17	I	23	24	1.210	
17	II	24	24	1.198	
17	III	25	25	1.141	1.183
18	I	25	25	1.187	
18	II	24	24	1.155	
18	III	24	25	1.131	1.158
21	I	25	23	1.212	
21	II	24	24	1.174	
21	III	24	24	1.163	1.183
23	I	19	19	1.183	
23	II	25	22	1.191	
23	III	19	24	1.192	
23	IV	23	23	1.211	1.194
Mean of 22 sets				s. 1.199 ± 0.005	

Assuming the wave-times in either direction to be equal, this mean difference of $1^s.199 \pm 0^s.005$ between the west-east and east-west longitude results, represents double the wave-time of a signal through the cable, plus the sum of the armature-times of the galvanometers, plus the sum of the personal errors in noting the signals at either end.

These armature-times and personal errors combined, as shown in Section VII, were subjected to exact measurement and found to be $0^s.259 \pm 0^s.002$ and $0^s.238 \pm 0^s.004$ for Messrs. Goodfellow and Blake respectively. Deducting their sum, $0^s.497 \pm 0^s.004$ from the mean difference, $1^s.199 \pm 0^s.005$, we have $0^s.702 \pm 0^s.006$ for the double, or its half, $0^s.351 \pm 0^s.003$ for the actual wave-time of a signal through the cable from Brest to St. Pierre.

The following data relating to the Brest–St. Pierre cable were kindly furnished by Mr. George C. Ward, manager at St. Pierre:

Length of cable, Brest to St. Pierre, 2,584 knots (1 knot = 6,087 feet). Weight per knot of gutta-percha, 400 pounds; diameter, in thousandths of an inch, or mills, 470; mean resistance (at 24° Cent.) per knot, in megohms, 235. Weight per knot of copper conductor, 400 pounds; diameter, in mills, 168; resistance per knot, in ohms, 3.16; specific conducting power, compared with pure copper at 100, 94.33; electro-static capacity per knot, in microfarads, 0.4295.

Resistance of galvanometers used in exchanging longitude and personal-error signals, 3,000 ohms each. Galvanometer mirrors suspended by silk fiber in clock-oil. Battery on first two nights of exchange consisted of 30 Daniells cells; on last five nights of 10 Menotti cells. The relative electro-motive forces of a single Daniells and Menotti cell were 35 and 25 respectively.

SECTION IX.

BREST—PARIS AND BREST—GREENWICH.

The Brest chronometer was compared with the clocks at Paris and Greenwich by means of arbitrary signals sent over the line and recorded on the chronograph at each station. These signals were sent for five minutes at approximate intervals of five seconds, the intervals being purposely varied so as to give different fractional readings.

At 11 o'clock p. m., Greenwich began sending to Brest; then Brest sent to Greenwich; next Brest to Paris; and finally Paris to Brest.

Between Greenwich and Brest but one series of signals was exchanged on each night, as the free use of the cable could not be granted for more than ten minutes. Between Brest and Paris, however, a wire was placed at the disposal of the party from 8 o'clock p. m. for the night; and generally two series of exchanges were obtained.

Both Greenwich and Paris worked with the local circuit open, recording "makes"; while Brest worked with a closed local circuit, recording "breaks." To obviate this difficulty, while exchanging time-signals, the local circuit at Brest was passed through the local connections of a Morse recorder and the insulated end of a Morse key, in such a manner as to be broken at the instant the main circuit between Greenwich and Paris was closed.

Fig. 5 shows the connections for recording time-signals received from Greenwich or Paris on the Brest chronograph. The screw A carries a spiral spring, which supports the armature B and causes it to bear against screw C. A make-circuit signal arriving from the sending station passes through bobbins D and attracts the armature B, thus breaking the local circuit at screw C.

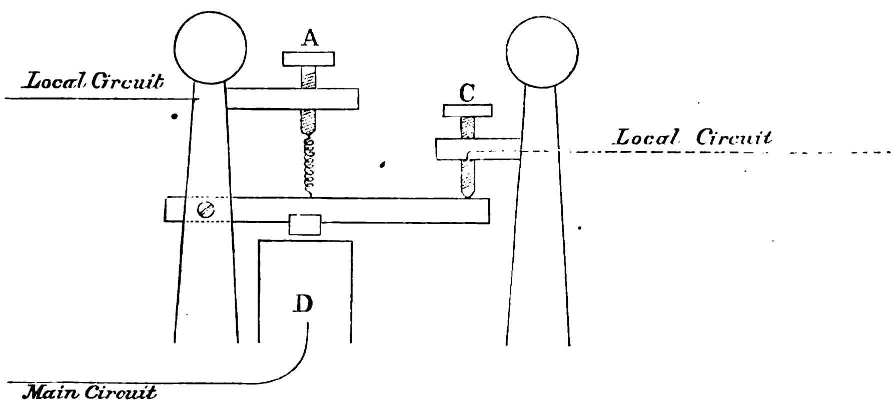


FIG. 5.

Fig. 6 shows the connections for recording on the Brest chronograph time-signals sent to Greenwich or Paris. A bit of insulated copper wire, W, was passed through the end of bar B and adjusted so as to bear on plate L when the key was at rest. The main circuit was attached in the usual way, so that when the bar B was depressed at P the main circuit was closed at N and the local circuit broken at L. In sending time-signals the bar was depressed by a sharp, quick blow and the pass from S to N did not exceed five hundredths of an inch.

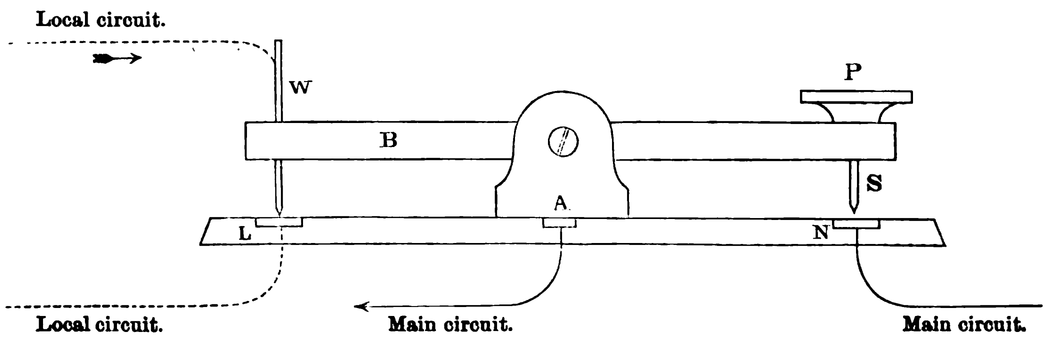


FIG. 6.

With Paris, time-signals were exchanged on nine nights, the resulting differences of longitude being as follows:

Brest and Paris, 1872.

	m. s.	s.
July 1	27 18.228	
3	18.268	
4	18.188	
5	18.314	
9	18.360	
19	18.190	
20	18.336	
21	18.206	
22	18.162	
Mean observed difference of longitude	27 18.250	± 0.016
Personal equation Blake–Folain	—0.041	± 0.034
Difference of longitude	27 18.209	± 0.038

With Greenwich, time-signals were exchanged on five nights, the resulting differences of longitude being as follows:

Brest and Greenwich, 1872.

	m. s.	s.
July 1	17 57.146	
3	57.122	
4	57.118	
5	57.054	
11	57.026	
Mean observed difference of longitude	17 57.093	± 0.015
Personal equation, Blake–Greenwich standard observer	+0.061	± 0.016
Difference of longitude	17 57.154	± 0.022

SECTION X.

PERSONAL EQUATION, BLAKE–FOLAIN.

As soon as the observations at Brest were finished, Mr. Blake transported his instruments to Paris and mounted the transit upon a pier which had been constructed for the purpose. This pier was in the garden to the southward of the National Observatory, exactly 1.40 meters ($0^s.005$) west and about 30 meters south of the *lunette méridienne* used by the Paris observer during the exchanges with Brest. The circuit-breaking chronometer was placed in a cellar beneath the observatory, and the chronograph in a separate building.

Messrs. Folain and Blake then determined the time with their own instruments after their own methods, and compared their time-keepers by the method used between Paris and Brest, thus obtaining a personal-equation difference which included all peculiarities that might have arisen from instrumental causes.

Paris, 1872.

		s.
August 16	Blake west of Folain,	— 0.138
17	Blake west of Folain,	+ 0.070
18	Blake west of Folain,	+ 0.168
19	Blake west of Folain,	+ 0.073
20	Blake west of Folain,	+ 0.055

			s.
Mean	Blake west of Folain,	+ 0.046	± 0.034
Actual difference	Blake west of Folain,	— 0.005	
Personal-equation difference, Blake west of Folain		0.041	± 0.034

The finally adopted personal-equation difference being—

Blake west of Folain, $0^s.041. \pm 0^s.034$.

It is obvious that an observed difference of longitude between these two observers must be *increased* or *diminished* according as Blake occupies the *eastern* or *western* station.

SECTION XI.

PERSONAL EQUATION, BLAKE AND GREENWICH STANDARD OBSERVER, AND LONGITUDE, GREENWICH—PARIS.

After finishing the personal-equation observations at Paris, Mr. Blake went to Greenwich for the purpose of comparing his personal equation with that of the Greenwich observers. His transit-instrument was mounted in a temporary observatory upon a pier which had been erected for the purpose by order of the astronomer royal. The chronograph was placed in an adjacent building and the circuit-breaking chronometer found a secure resting-place beside the Greenwich standard sidereal clock in the cellar of the building used as a magnetic observatory.

These arrangements having been made, Mr. Blake again observed in his accustomed way, comparing his time-keeper telegraphically with the Greenwich clock, and likewise with the clock at Paris, where Mr. Folain was still keeping up his corresponding observations.

The site of the Coast Survey transit-pier at Greenwich has since been marked by a slab of marble bearing the inscription:

HILGARD.

It is $0^s.160$ west and $1^s.74$ south of the Greenwich transit-circle which is mounted in the meridian of Greenwich, from which all longitudes are reckoned.

Following is a list of the Greenwich observers who were engaged in the longitude-work, Mr. Criswick being the "standard observer" to whom the observations of all the others were referred:

Mr. George Stickland Criswick	Signature, St'd.
Mr. William Ellis	" E.
Mr. William Thynne Lynn	" L.
Mr. James Carpenter	" J. C.
Mr. Henry James Carpenter	" H. C.
Mr. Joseph Pyle Potts	" P.
Mr. Charles Augustus Jenkins	" J.

Mr. Criswick, Mr. Ellis, Mr. Lynn, and Mr. James Carpenter were the assistants in the astronomical department of the observatory, who generally observed with the transit-circle; while occasional observations were made by Mr. H. J. Carpenter, Mr. Potts, and Mr. Jenkins, who were employed as computers in the observatory.

The results for personal-equation differences deduced from nine nights' work were as follows:

Greenwich, 1872.

		s.	
August 28,	Blake east of Greenwich standard observer	0.238	
" 30,	" " " " "	0.306	
" 31,	" " " " "	0.290	
September 3,	" " " " "	0.160	
" 4,	" " " " "	0.286	
" 5,	" " " " "	0.183	
" 6,	" " " " "	0.120	
" 7,	" " " " "	0.150	
" 9,	" " " " "	0.258	
	Mean, Blake east of Greenwich standard observer	0.221	± s. 0.016
	Actual difference, Blake east of Greenwich standard observer	0.160	
	Personal equation difference, Blake east of Greenwich standard observer,	0.061	± s. 0.016

The finally-adopted personal-equation difference being—

Blake east of Greenwich standard observer, $0^{s}.061 \pm 0^{s}.016$,

it is obvious that an observed difference of longitude between these two observers must be *diminished* or *increased* according as Blake occupies the *eastern* or *western* station.

The longitude results deduced from time-signals exchanged on five nights with Paris are as follows:

Greenwich and Paris, 1872.

		m.	s.
August	28	9	21.024
	31		20.980
September	7		21.066
	9		20.929
	10		21.004

	m.	s.
Mean observed difference of longitude	9	21.001 ± 0.016
Personal equation, Blake—Folain		− 0.041 ± 0.034
Reduction of Coast Survey transit to Greenwich transit-circle,		+ 0.160
Difference of longitude	9	21.120 ± 0.038

SECTION XII.

PERSONAL EQUATIONS OF COAST SURVEY OBSERVERS.

Mr. Blake returned to the United States late in September, and during the following month joined Messrs. Goodfellow and Smith at Cambridge, and made with them an extended series of personal-equation observations.

Three piers were constructed in Mr. Smith's observatory, permitting the three transit-instruments used in the longitude-work to be mounted in the same meridian at one time. The personal equations were then compared by each observer determining the time with his own instrument, in his accustomed manner, using the same stars.

Each observer recorded his observations upon his own chronograph, but the three chronographs were graduated by the same clock through a suitably-arranged relay. The different systems of lines with which the transit-instruments were provided, as well as the fact that no two of the observers could work with a common focus, prevented a satisfactory determination of the personal equations by the "alternate-tally" method.

The results obtained from six nights' work by the method just described are as follows:

Goodfellow, Blake, and Smith.

Date.	S. – B.	G. – S.	G. – B.
1872.	s.	s.	s.
October 19	−0.005	+0.004	−0.001
21	−0.063	+0.069	+0.006
28	−0.052	+0.071	+0.019
29	[+0.113]	[−0.064]	+0.049
November 1	−0.075	+0.057	−0.018
2	[+0.151]	[−0.084]	+0.067

The results for (S. — B.) and (G. — S.) on October 29 are rejected on account of their great difference from the mean, and the similar results on November 2 are rejected because on that date Mr. Smith observed while suffering from a very severe headache. After making these rejections, the mean values with their probable errors are—

	s.	s.
(S. — B.)	− 0.049	± 0.010
(G. — S.)	+ 0.050	± 0.011
(G. — B.)	+ 0.020	± 0.009

These values fail to satisfy the equation (S. — B.) + (G. — S.) — (G. — B.) = 0 by $0^s.019$, which have been arbitrarily divided and applied as corrections to the observed values, as follows:

	s.	*s.*	*s.*
(S. — B.)	Observed value, — 0.049;	correction, + 0.007;	adopted value, — 0.042.
(G. — S.)	Observed value, + 0.050;	correction, + 0.007;	adopted value, + 0.057.
(G. — B.)	Observed value, + 0.020;	correction, — 0.005;	adopted value, + 0.015.

To render obvious the application of these personal-equation differences to the longitude results, they are stated as follows:

	s.	*s.*
*Blake puts himself east of Smith	0.042 ±	0.010
Smith puts himself west of Goodfellow	0.057 ±	0.011
Blake puts himself west of Goodfellow	0.015 ±	0.009

SECTION XIII.

OBSERVATIONS FOR FLEXURE OF TRANSIT AXES.

While the three transit instruments of the American observers were mounted in the same meridian, as described in the preceding section, advantage was taken of the opportunity thus afforded of testing them as to flexure of their axes. This was done by comparing in each the line of collimation as indicated by reversals, right and left, with that resulting from revolving it about its axis, using the two other instruments as collimators, each being in turn placed in the middle.

The collimation resulting from the observation of circumpolar stars in the direct and reversed positions was likewise compared with that from reversal in the horizontal direction of the telescope, using the adjoining one as a mark.

The results showed that there were no sensible inequalities of flexure in the instruments.

SECTION XIV.

FINAL DISCUSSION OF THE RESULT FOR LONGITUDE DIFFERENCES—BREST, GREENWICH, AND PARIS.

The direct results corrected for personal equation, with their probable errors, are as follows:

	m.	*s.*	*s.*
Brest — Greenwich	17	57.154 ±	0.022
Greenwich — Paris	9	21.120 ±	0.038
Brest — Paris	27	18.209 ±	0.038

The longitude of the "*Tour de St. Louis*," at Brest, from the "meridian of France" (the center of the Paris Observatory) was determined telegraphically in 1863, under the direction of Mr. Le Verrier, and found to be $27^m\ 18^s.49$. To reduce this result to our own points of reference we must add $0^s.12$ at Paris and deduct $0^s.44$ at Brest, thereby obtaining $27^m\ 18^s.17$ as a second and independent determination of the longitude of the Coast Survey transit at Brest from the *lunette méridienne* of the Paris Observatory. The elaborate observations and computations from which this result is derived are published in full in the "*Annales de l'Observatoire de Paris*," VIII, 1866, p. 279. Assuming its probable error to be the same as that of our own result, we have—

	m.	*s.*	*s.*
Brest — Paris, 1863	27	18.170 ±	0.038
Brest — Paris, 1872	27	18.209 ±	0.038
Brest — Paris, mean	27	18.190 ±	0.027

* The adoption of this value seems to be further justified by the results of subsequent determinations of the personal-equation differences between Messrs. Blake and Smith. Observations for this purpose were made during November, 1873, and January and February, 1877, with the following results:

	s.
1873, Blake east of Smith	0.070
1877, Blake east of Smith	0.036

In the "longitude triangle," Brest, Greenwich, and Paris, we now have—

	m.	s.	s.	Weight.
Brest — Greenwich..........	17	57.154 ±	0.022	10
Greenwich — Paris..........	9	21.120 ±	0.038	7
Brest — Paris................	27	18.190 ±	0.027	9

which values do not satisfy the equation—

Brest — Paris + Paris — Greenwich + Greenwich — Brest=0

by $0^s.084$. Distributing this residual among the three values, with due regard to weights, we obtain the most probable values that can finally be assigned, as follows:

	m.	s.	s.
Brest — Greenwich..........	17	57.130 ±	0.022
Greenwich — Paris..........	9	21.086 ±	0.038
Brest — Paris..........	27	18.216 ±	0.027

SECTION XV.

FINAL COMBINATIONS OF THE LONGITUDE DIFFERENCES DEDUCED FROM THE OBSERVATIONS OF 1872, 1870, AND 1866.

The several links of the 1872 chains of longitudes are presented for convenience in the following order, corrected for personal equation.

	h.	m.	s.	s.
(1) Cambridge transit, 1872, west of St. Pierre transit	0	59	48.695 ±	0.025
(2) St. Pierre transit west of Brest transit, 1872	3	26	45.254 ±	0.027
(3) Brest transit, 1872, west of Greenwich transit-circle		17	57.130 ±	0.022
(4) Brest transit, 1872, west of Paris *lunette méridienne*.........		27	18.216 ±	0.027
(5) Greenwich transit-circle west of Paris *lunette méridienne*....		9	21.086 ±	0.038
(6) Cambridge transit, 1872, west of Harvard Observatory dome,			0.096 ±	0.000
(7) St. Pierre transit east or west of St. Pierre longitude-station,			0.000	
(8) Brest transit, 1872, east of *Tour de St. Louis*................			0.440 ±	0.000
(9) Greenwich transit-circle east or west of Greenwich meridian,			0.000	
(10) Paris *lunette méridienne* east of the meridian of France			0.120 ±	0.000

Combining (5), (9), and (10), we have Greenwich (meridian) west of Paris (meridian of France) 9^m, $20^s.966 \pm 0^s.038$.

Combining (3), (8), and (9), we have Brest (*Tour de St. Louis*) west of Greenwich (meridian), $17^m\ 57^s.570 \pm 0^s.022$.

Combining (4), (8), and (10), we have Brest (*Tour de St. Louis*) west of Paris (meridian of France) 27^m, $18^s.536 \pm 0^s.27$.

Combining (2), (3), (7), and (9), we have St. Pierre (longitude-station) west of Greenwich (meridian), $3^h\ 44^m\ 42^s.384 \pm 0^s.035$.

Combining (2), (4), (7), and (10), we have St. Pierre (longitude-station) west of Paris (meridian of France), $3^h\ 54^m\ 3^s.350 \pm 0^s.038$.

Combining (1), (2), (3), (6), and (9), we have Cambridge (Harvard Observatory dome) west of Greenwich (meridian), $4^h\ 44^m\ 30^s.983 \pm 0^s.043$.

Combining (1), (2), (4), (6), and (10), we have Cambridge (Harvard Observatory dome) west of Paris (meridian of France), $4^h\ 53^m\ 51^s.949 \pm 0^s.046$.

The longitude of Cambridge from Greenwich, as determined by the operations of 1870, is obtained by the following combination:

	h.	m.	s.
Cambridge transit, 1870—Duxbury transit.....	0	1	50.23 ± 0.02
Reduction of Cambridge transit, 1870 to Harvard Observatory dome ..			—0.04 ± 0.00
Duxbury transit—Brest transit, 1870..................................	4	24	42.87 ± 0.05
Reduction of Brest transit, 1870, to Brest transit, 1872..............			+ 0.79 ± 0.00
Brest transit, 1872—Greenwich (meridian)................................		17	57.13 ± 0.02
Cambridge (Harvard Observatory dome)—Greenwich (meridian)....	4	44	30.98 ± 0.06

The figures for Cambridge — Duxbury and Duxbury — Brest are taken from No. XVI, Memoirs of the American Academy, Cambridge, 1873, by Prof. Joseph Lovering, who had charge of the computations. By reference to that publication, it will be seen that during the 1870 longitude-work the ends of the two cables were joined at St. Pierre, by bringing their several condensers into contact, and that the cable time-signals were then exchanged directly between Brest and Duxbury. The method of transmission was thus quite different from that employed in 1872, and the close agreement of results can only be held as dissipating all doubt as to the sensible equality of the transmission or wave-time of signals sent in opposite directions.

We will finally consider the longitude of Cambridge from Greenwich, as determined through the Ireland-Newfoundland cables in 1866, by Dr. B. A. Gould. A full account of his operations is published in the United States Coast Survey Report for 1867, and also in Vol. XVI of the Smithsonian Contributions. The results there given lack one link of being complete, and that is the difference of personal equation between Mosman, the observer at Foilhommerum, and the standard observer at Greenwich. This defect we have endeavored to supply, as far as is practicable after the lapse of some years, through the personal-equation differences between Messrs. Mosman, Blake, and the Greenwich observers, in the following manner: The well-ascertained equation between Blake and Mosman is that Blake places himself $0^s.09$ west of Mosman. Blake, moreover, places himself $0^s.06$ east of the present Greenwich standard observer (Criswick), who, in turn, places himself $0^s.11$ west of the standard observer of 1867 (Dunkin). Hence we deduce that Mosman placed himself $0^s.04$ east of Dunkin, and the former difference of longitude between Greenwich and Foilhommerum must be increased by that amount.

The figures given in the publications above referred to require some other corrections in consequence of the personal-equation corrections having been applied with the wrong sign. We therefore recite the several links of the combination, as follows:

	h.	m.	s.
1851, Cambridge (Harvard Observatory dome) — Bangor	0	9	23.06
1857, Bangor — Calais		6	0.31
1866, Calais — Heart's Content		55	37.97
1866, Heart's Content — Foilhommerum	2	51	56.32
1866, Foilhommerum — Greenwich (meridian)		41	33.33
Cambridge (Harvard Observatory dome) — Greenwich (meridian)	4	44	30.99

Considering the number of separate determinations entering into this result, we cannot well ascribe to it a probable error less than $\pm 0^s.10$, even when dismissing all further question of the inequality of transmission-times in opposite directions. The close agreement of the three independent determinations made in different years is therefore no less surprising than it is satisfactory. We have—

Longitude of Cambridge (Harvard College Observatory dome) west of Greenwich (meridian)—

	h.	m.	s.	s.
1866	4	44	30.99	±0.10
1870			30.98	±0.06
1872			30.98	±0.04
Mean	4	44	30.98	±0.04

This mean value may be referred to Paris (meridian of France) by adding $9^m\ 20^s.97 \pm 0.04$, which gives—

Cambridge—Paris .... $4^h\ 53^m\ 51^s.95 \pm 0^s.06$

The following table gives the adopted longitudes, derived from the preceding data:

Finally adopted longitudes from observations of 1866, 1870, *and* 1872.

City.	Point of reference.	Longitude west of Greenwich. [Meridian of transit-circle at Royal Observatory.]		Longitude west of Paris. [Meridian of France or center of Paris Observatory.]	
		h. m. s.	Prob. error. *s.*	*h. m. s.*	Prob. error. *s.*
Greenwich......	Transit-circle at Royal Observatory........	......	....	0 9 20.97	±0.04
Brest..........	Center of *Tour de St. Louis*...............	0 17 57.57	±0.02	0 27 18.54	±0.03
St. Pierre.......	Coast Survey longitude-station of 1872	3 44 42.38	±0.04	3 54 3.35	±0.04
Cambridge......	Center of Harvard College Observatory dome.	4 44 30.98	±0.04	4 53 51.95	±0.06

It is proper to state here that during the progress of the work which has been detailed in the preceding pages, exchanges of signals were also made between the United States Naval Observatory at Washington, and the observatories at Cambridge and St. Pierre. The results of these observations are given elsewhere and are combined with the elaborate determination of longitude between Washington and Cambridge, made by a joint operation of the Coast Survey, the Harvard College Observatory, and the United States Naval Observatory in 1867. The result of the latter was:

	m. s.	*s.*
Washington — Cambridge..	23 41.11	± 0.03

the points of reference being the centers of the domes of the observatories.

Combining this value with the preceding we obtain, viz:

	h. m. s.	*s.*
Washington — Greenwich	5 8 12.09	±0.05
Washington — Paris	5 17 33.06	±0.07

which is subject, however, to any small change that may arise from the determination of 1872.

PART II.

REDUCTION OF THE OBSERVATIONS MADE FOR THE TRANSATLANTIC LONGITUDE DETERMINATIONS OF 1872.

The computations of all observations at Cambridge and St. Pierre were made, under the direction of Prof. Joseph Lovering, by Mr. Lucius Brown. The instrumental constants were all determined on the supposition of a possible change in the azimuth at every reversal. For a full elucidation of the formulæ used, reference may be made to a paper on the "Determination of Time by Means of the Transit-Instrument," prepared for the Coast Survey Manual, by Assistant C. A. Schott, and published as Appendix No. 9 to the Coast Survey Report of 1866. Also, to addendum to this paper, by the same author, published as Appendix No. 10 to the Coast Survey Report of 1868.

The observations of Mr. Blake at Brest, Paris, and Greenwich were computed in the following manner: The chronograph-sheets having been independently read by two persons, and the readings collated, each evening's work was reduced by Mr. Blake on the plan of deriving the collimation and the azimuthal deviation of the transit-instrument from all the observed stars by means of the usual normal equations, giving equal weight to all the stars. The clock-correction was then finally determined from stars of less than 60° declination by applying the instrumental corrections previously obtained.

In a more elaborate second computation, made by Prof. R. Keith, each conditional equation was affected by a weight depending upon the star's declination, according to a law derived from the observations themselves, which is expressed by the empirical formula—

$$E^2 = \sqrt{1.21 \sec \delta \sec (\delta - \varphi)}$$

and which gives—

For Brest.		*For Greenwich.*	
δ	p	δ	p
$+0^\circ$	0.95	$+0^\circ$	0.88
10	0.99	10	0.95
20	1.00	20	0.99
30	0.97	30	1.00
40	0.88	40	0.96
50	0.79	50	0.89
60	0.65	60	0.78
70	0.48	70	0.63
80	0.28	80	0.43

Moreover, separate values were deduced from the azimuthal deviation before and after each reversal. The formulæ used were, with the exception of the empirical one for weights, the same as those already referred to as having been used at Cambridge and St. Pierre.

The resulting clock-corrections obtained by the two methods of computation show a very good agreement, the average difference being only $0^s.017$. The sum of the residuals for each star is less in the second than in the first in the ratio of twenty-six to thirty-one, but it must be noted that the observations should be better represented in something near that ratio, in consequence of the introduction of four instead of three variables in the equation; so that but a small improvement can be ascribed to the use of weights. This second computation has, however, been adopted as final, and the observations and reductions as herewith published are prepared from it.

The right ascensions used in computing the observations of the American observers are a mean of those of the Washington Observatory from 1862 to 1867, and of the Harvard College Observatory from June to November, 1872. They do not agree precisely with either the Greenwich or the Paris right ascensions, but the differences are small. It would certainly have been desirable to use the same data in the computation of the observations at all the stations, but as Greenwich and Paris did not agree in their standard places, it was thought best to use the list adopted for the Coast Survey longitude-work and let the accidental variations be merged in the errors of observation, while any systematic difference in the places would form part of the personal equation. The longitudes cannot, in any sensible degree, be affected by the differences adverted to.

The computations of observations at the National Observatory at Paris were made by Mr. L. F. Folain and are published herewith in their original form, excepting the explanatory notes, which have been translated from French into English.

At Greenwich, the observations and computations connected with the longitude-work will be found in the regular publications of the Royal Observatory. There are published herewith a table of clock-errors and rates, and the results of observations for personal-equation differences between the several observers.

The computations are arranged in the following order:

Coast Survey clock and instrumental corrections at Cambridge.
Coast Survey clock and instrumental corrections at St. Pierre.
Coast Survey clock and instrumental corrections at Brest.
Coast Survey clock and instrumental corrections at Paris.
Coast Survey clock and instrumental corrections at Greenwich.
Clock errors and rates at Royal Observatory, Greenwich.
Differences of personal equation between the Greenwich observers.
Clock and instrumental corrections at National Observatory, Paris.
Longitude, Cambridge — St. Pierre.
Longitude, St. Pierre — Brest.
Longitude, Brest — Greenwich.
Longitude, Brest — Paris.
Longitude, Greenwich — Paris.
Personal error in noting cable time-signals, St. Pierre.
Personal error in noting cable time-signals, Brest.
Personal-equation differences, Folain — Blake.
Personal-equation differences, Greenwich standard observer — Blake.
Personal-equation differences, Goodfellow — Blake — Smith.

Computation of observations for clock and instrumental corrections at Cambridge, Mass., 1872.

(Observer, Edwin Smith.—An asterisk is affixed to the clock-corrections derived from stars of more than 65° N. declination.)

Dates.	Stars.	L. p.	Observed time of transit.			Corrections. Rate.	Aberration.	Level.	Azimuth.	Collimation.	Clock-time of meridian transit.			Right ascension.			Clock correct.
			h.	m.	s.	s.	s.	s.	s.	s.	h.	m.	s.	h.	m.	s.	s.
1872. July 19	τ Herculis	E.	16	16	00.59	—0.01	—0.02	—0.08	—0.02	+0.11	16	16	00.57	16	15	55.44	—5.13
	η Draconis	E.		22	23.13	— .01	— .03	— .08	— .11	+ .16		22	23.06	16	22	17.92	5.14
	A Draconis	E.	16	28	22.49	— .01	— .04	— .08	— .20	+ .21	16	28	22.37	16	28	17.23	5.14*
	α Ophiuchi	E.	17	29	06.61	.00	— .02	— .05	+ .08	+ .08	17	29	06.70	17	29	01.44	5.26
	ω Draconis	E.		37	50.66	.00	— .04	— .16	— .20	+ .21		37	50.47		37	45.27	5.20*
	μ Herculis	E.		41	34.01	.00	— .02	— .06	+ .05	+ .08		41	34.06		41	28.87	5.19
	ψ Draconis	E.		44	22.22	.00	— .05	— .16	— .26	+ .25		44	22.00		44	16.64	5.36*
	γ Draconis	E.	17	53	45.59	.00	— .02	— .08	— .04	+ .12	17	53	45.57		53	40.25	5.32
	22 Camelopardalis, L. C	W.	18	04	46.88	.00	+ .05	+ .10	+ .78	+ .21	18	04	48.02	18	04	42.45	5.57*
	η Serpentis	W.		14	48.31	.00	— .02	— .07	+ .21	— .07		14	48.36		14	43.22	5.14
	1 Aquilæ	W.		28	21.74	.00	— .01	— .07	+ .23	— .08		28	21.81		28	16.58	5.23
	α Lyræ	W.		32	43.75	.00	— .02	— .14	+ .03	— .10		32	43.52		32	38.41	5.11
	51 Cephei, L. C	W.	18	39	22.94	.00	+ .32	+1.22	+4.74	+1.56	18	39	30.78	18	39	25.60	5.18*
July 20	ε Coronæ Borealis	E.	15	52	23.99	— .01	— .02	—0.13	+0.01	+0.08	15	52	23.92	15	42	18.80	5.12
	β^1 Scorpii	E.	15	58	06.49	— .01	— .02	— .07	+ .03	+ .07	15	58	06.49	15	58	01.42	5.07
	δ Ophiuchi	E.	16	07	44.94	— .01	— .02	— .10	+ .02	+ .07	16	07	44.90	16	07	39.94	4.96
	τ Herculis	E.		16	00.60	— .01	— .02	— .23	.00	+ .10		16	00.44		15	55.42	5.02
	η Draconis	E.		22	23.03	— .01	— .03	— .32	— .02	+ .15		22	22.80		22	17.89	4.91
	A Draconis	E.		28	22.57	— .01	— .04	— .40	— .03	+ .20		28	22.29		28	17.18	5.11*
	κ Ophiuchi	W.		51	43.54	.00	— .02	— .21	+ .02	— .07		51	43.26		51	38.31	4.95
	ε Ursæ Minoris	W.	16	59	23.24	.00	— .11	—1.36	— .18	— .53	16	59	21.06	16	59	16.17	4.89*
	α^1 Herculis	W.	17	08	55.74	.00	— .02	—0.20	+ .02	— .07	17	08	55.47	17	08	50.45	5.02
	44 Ophiuchi	W.		18	40.47	.00	— .02	— .09	+ .04	— .08		18	40.32		18	35.33	4.99
	β Draconis	W.		27	40.16	.00	— .02	— .29	— .01	— .12		27	39.72		27	34.68	5.04
	α Ophiuchi	W.		29	06.62	.00	— .02	— .16	+ .02	— .07		29	06.39		29	01.44	4.95
	ω Draconis	W.		37	51.00	.00	— .04	— .39	— .05	— .20		37	50.32		37	45.23	5.09*
	μ Herculis	W.		41	34.18	.00	— .02	— .16	+ .01	— .08		41	33.93		41	28.86	5.07
	ψ^1 Draconis	W.	17	44	22.53	.00	— .05	— .41	— .06	— .23	17	44	21.78	17	44	16.60	5.18*
	1 Aquilæ	W.	18	28	21.71	+ .01	— .02	— .05	+ .03	— .07	18	28	21.61	18	28	16.58	5.03
	α Lyræ	W.		32	43.69	+ .01	— .02	— .10	.00	— .09		32	43.49		32	38.41	5.08
	51 Cephei, L. C	W.		39	27.50	+ .01	+ .32	+ .96	+ .61	+1.47		39	30.87		39	25.90	4.97*
	β Lyræ	W.		45	28.61	+ .01	— .02	— .10	+ .01	—0.09		45	28.42		45	23.32	5.10
	σ Sagittarii	W.		47	27.11	+ .01	— .02	— .04	+ .04	— .08		47	27.02		47	22.02	5.00
	50 Draconis	W.		50	39.54	+ .01	— .06	— .34	— .08	— .28		50	38.79		50	33.98	4.81*
	ζ Aquilæ	W.	18	59	38.81	+ .01	— .02	— .11	+ .02	— .07	18	59	38.64	18	59	33.63	5.01
	d Sagittarii	E.	19	10	15.89	+ .01	— .02	— .08	+ .06	+ .08	19	10	15.94	19	10	10.98	4.96
	δ Draconis	E.	19	12	39.81	+ .01	— .04	— .38	— .07	+ .19	19	12	39.52	19	12	34.55	4.97*
July 21	β Ophiuchi	W.	17	37	15.89	.00	— .02	— .04	— .06	— .06	17	37	15.71	17	37	10.85	4.86
	μ Herculis	W.		41	33.83	.00	— .02	— .05	— .03	— .07		41	33.66		41	28.86	4.80
	γ Draconis	W.	17	53	45.27	.00	— .02	— .07	+ .02	— .10	17	53	45.10	17	53	40.22	4.88
	72 Ophiuchi	W.	18	01	23.89	.00	— .02	— .04	— .05	— .06	18	01	23.72	18	01	18.83	4.89
July 22	τ Herculis	E.	16	15	59.92	— .01	— .02	+ .01	+ .02	+ .08	16	15	60.00	16	15	55.38	4.62
	η Draconis	E.		22	22.18	— .01	— .03	— .01	+ .13	+ .12		22	22.38		22	17.82	4.56
	A Draconis	E.		28	21.27	— .01	— .04	— .05	+ .24	+ .16		28	21.57		28	17.09	4.48*
	ζ Ophiuchi	E.		30	13.17	— .01	— .02	— .01	— .15	+ .06		30	13.04		30	08.42	4.62
	η Herculis	E.		38	36.98	— .01	— .02	— .05	— .01	+ .07		38	36.96		38	32.26	4.70
	κ Ophiuchi	E.		51	43.06	.00	— .02	— .03	— .10	+ .06		51	42.97		51	38.30	4.67
	ε Ursæ Minoris	E.	16	59	19.56	.00	— .11	— .11	+ .89	+ .41	16	59	20.64	16	59	15.91	4.73*
	α^1 Herculis	E.	17	08	55.20	.00	— .02	.00	— .09	+ .06	17	08	55.15	17	08	50.44	4.71
	44 Ophiuchi	E.		18	40.20	.00	— .02	.00	— .19	+ .06		18	40.05		18	35.32	4.73
	Groom. 966, L. C	W.		22	40.06	.00	+ .06	+ .04	— .36	+ .22		22	40.02		22	35.37	4.65*
	β Draconis	W.		27	39.32	.00	— .02	— .04	+ .03	— .09		27	39.20		27	34.65	4.55
	ω Draconis	W.		37	49.89	.00	— .04	— .05	+ .13	— .16		37	49.77		37	45.16	4.61*
	μ Herculis	W.		41	33.63	.00	— .02	— .02	— .03	— .06		41	33.50		41	28.85	4.65
	ψ^1 Draconis	W.		44	21.31	.00	— .05	— .04	+ .17	— .18		44	21.21		44	16.51	4.70*
	γ Draconis	W.	17	53	44.99	.00	— .03	— .01	+ .03	— .09	17	53	44.89	17	53	40.21	4.68
	μ^1 Sagittarii	W.	18	06	13.50	+ .01	— .02	.00	— .10	— .06	18	06	13.33	18	06	08.70	—4.63

Computation of observations for clock and instrumental corrections, &c.—Continued.

Dates.	Stars.	L. p.	Observed time of transit.			Corrections. Rate.	Aberration.	Level.	Azimuth.	Collimation.	Clock-time of meridian transit.			Right ascension.			Clock correct.
1872.			h.	m.	s.	s.	s.	s.	s.	s.	h.	m.	s.	h.	m.	s.	s.
July 22	η Serpentis	W.	18	14	48.03	+0.01	−0.02	−0.01	−0.07	−0.06	18	14	47.48	18	14	43.22	−4.66
	1 Aquilæ	W.		28	21.41	+.01	−.02	−.01	−.08	−.06		28	21.25		28	16.58	4.67
	α Lyræ	W.	18	32	43.24	+.01	−.02	−.02	−.01	−.07	18	32	43.13	18	32	38.40	4.73
July 23	A Draconis	E.	16	28	20.81	.00	−.04	−.04	+.22	+.14	16	28	21.09	16	28	17.04	4.05*
	η Herculis	E.		38	36.62	.00	−.02	−.02	−.01	+.07		38	36.64		38	32.24	4.40
	ε Ursæ Minoris	E.	16	59	19.07	.00	−.11	−.10	+.82	+.38	16	59	20.06	16	59	15.77	4.29*
July 24	ζ Ursæ Minoris	W.	15	48	47.15	−.01	−.08	−.23	+.83	−.23	15	48	47.43	15	48	43.69	3.74*
	ε Coronæ Borealis	W.	15	52	23.12	−.01	−.02	−.06	−.09	−.05	15	52	22.89	15	52	18.75	4.14
	δ Ophiuchi	W.	16	07	44.42	−.01	−.01	−.05	−.21	−.05	16	07	44.09	16	07	39.91	4.18
	τ Herculis	W.		15	59.60	−.01	−.02	−.10	+.03	−.07		15	59.43		15	55.34	4.09
	η Draconis	W.		22	21.68	−.01	−.03	−.11	+.21	−.10		22	21.64		22	17.75	[3.89]
	A Draconis	W.		28	21.24	−.01	−.04	−.13	+.36	−.13		28	21.29		28	16.99	4.30*
	ζ Ophiuchi	W.		30	12.88	−.01	−.02	−.03	−.23	−.05		30	12.54		30	08.41	4.13
	η Herculis	W.		38	36.58	−.01	−.02	−.06	−.02	−.06		38	36.41		38	32.23	4.18
	κ Ophiuchi	W.		51	42.81	.00	−.02	−.04	−.16	−.05		51	42.54		51	38.29	4.25
	ε Ursæ Minoris	W.	16	59	19.14	.00	−.11	−.22	+1.38	−.36	16	59	19.83	16	59	15.64	4.19*
	α¹ Herculis	W.	17	08	54.94	.00	−.02	−.03	−0.14	−.05	17	08	54.70	17	08	50.43	4.27
	44 Ophiuchi	W.		18	39.90	.00	−.02	−.01	−.29	−.05		18	39.53		18	35.31	4.22
	Groom. 966, L. C	W.		22	40.01	.00	+.06	+.06	−1.00	+.19		22	39.35		22	35.54	3.81*
	β Draconis	E.		27	38.68	.00	−.02	−.02	+0.07	+.08		27	38.79		27	34.61	4.18
	ω Draconis	E.		37	48.72	.00	−.04	−.03	+.32	+.13		37	49.10		37	45.09	4.01*
	μ Herculis	E.		41	32.98	.00	−.02	−.01	−.07	+.05		41	32.93		41	28.84	4.09
	ψ¹ Draconis	E.		44	20.04	.00	−.05	−.04	+.42	+.16		44	20.53		44	16.42	4.11*
	γ Draconis	E.	17	53	44.21	.00	−.02	−.03	+.07	+.08	17	53	44.31	17	53	40.18	4.13
	μ¹ Sagittarii	E.	18	06	13.08	.00	−.02	−.01	−.25	+.05	18	06	12.85	18	06	08.70	4.15
	η Serpentis	E.		14	47.54	.00	−.02	−.01	−.19	+.05		14	47.37		14	43.22	4.15
	ψ Draconis	E.		23	29.09	.00	−.05	−.03	+.44	+.16		23	29.61		23	25.35	4.26*
	1 Aquilæ	E.		28	20.95	.00	−.02	−.01	−.20	+.05		28	20.77		28	16.59	4.18
	α Lyræ	E.		32	42.58	+.01	−.02	−.02	−.02	+.06		32	42.59		32	38.39	4.20
	51 Cephei, L. C	E.		39	35.70	+.01	+.32	+.23	−4.17	−1.00		39	31.09		39	26.93	4.16*
	σ Sagittarii	E.		47	26.44	+.01	−.02	.00	−0.27	+0.05		47	26.21		47	22.04	4.17
	50 Draconis	E.		50	37.39	+.01	−.06	−.04	+.56	+.19		50	38.05		50	33.83	4.22*
	50 Draconis	W.		50	38.00	+.01	−.06	.00	+.26	−.19		50	38.02		50	33.83	4.19*
	ζ Aquilæ	W.	18	59	38.00	+.01	−.02	.00	−.06	−.05	18	59	37.88	18	59	33.64	4.24
	d Sagittarii	W.	19	10	15.41	+.01	−.02	.00	−.11	−.05	19	10	15.24	19	10	11.00	4.24
	δ Draconis	W.		12	38.68	+.01	−.04	.00	+.14	−.13		12	38.66		12	34.49	4.17*
	τ Draconis	W.	19	18	08.32	+.01	−.05	.00	+.21	−.16	19	18	08.33	19	18	04.18	4.15*
July 25	α Coronæ Borealis	E.	15	29	21.68	.00	−.02	−.10	−.11	+.08	15	29	21.53	15	29	17.41	4.12
	α Serpentis	E.		38	03.58	.00	−.02	−.08	−.22	+.07		38	03.33		37	59.20	4.13
	β Serpentis	E.		40	22.53	.00	−.02	−.09	−.17	+.07		40	22.32		40	18.18	4.14
	ζ Ursæ Minoris	E.		48	46.76	.00	−.08	−.38	+1.07	+.34		48	47.71		48	43.58	4.13*
	ε Coronæ Borealis	E.		52	22.99	.00	−.02	−.10	−0.11	+.08		52	22.84		52	18.74	4.10
	θ Draconis	E.	15	59	35.31	.00	−.03	−.15	+.21	+.13	15	59	35.47	15	59	31.23	4.24
	φ Herculis	E.	16	04	50.00	.00	−.02	−.08	+.03	+.10	16	04	50.03	16	04	45.65	4.38
	τ Herculis	W.		15	59.51	.00	−.02	−.04	+.02	−.10		15	59.37		15	55.32	4.05
	ω Herculis	W.		19	36.48	.00	−.02	−.02	−.10	−.07		19	36.27		19	31.98	4.29
	α Scorpii	W.		21	39.98	.00	−.02	−.01	−.22	−.08		21	39.65		21	35.50	4.15
	A Draconis	W.		28	20.63	.00	−.04	−.07	+.26	−.19		28	20.64		28	16.94	3.70*
	ζ Ophiuchi	W.		30	12.89	.00	−.02	−.02	−.17	−.07		30	12.61		30	08.39	4.22
	η Herculis	W.		38	36.36	.00	−.02	−.03	−.01	−.09		38	36.21		38	32.21	4.00
	κ Ophiuchi	W.		51	42.62	.00	−.02	−.02	−.11	−.07		51	42.40		51	38.27	4.13
	ε Ursæ Minoris	W.	16	59	19.65	.00	−.11	−.34	+.99	−.51	16	59	19.68	16	59	15.49	4.19*
	α¹ Herculis	W.	17	08	54.77	.00	−.02	−.03	−.10	−.07	17	08	54.55	17	08	50.42	4.13
	ψ Herculis	W.		23	27.09	.00	−.02	−.03	+.03	−.10		23	26.97		23	22.59	4.38
	β Draconis	W.		27	38.86	.00	−.02	−.03	+.06	−.11		27	38.76		27	34.59	4.17
	ω Draconis	W.		37	49.40	.00	−.04	−.06	+.26	−.19		37	49.37		37	45.05	4.32*
	ψ¹ Draconis	W.		44	20.77	.00	−.05	−.06	+.34	−.23		44	20.77		44	16.38	4.39*
	γ Draconis	E.	17	53	44.41	0.00	−0.02	−0.03	+0.05	+0.11	17	53	44.52	17	53	40.16	−4.36

Computation of observations for clock and instrumental corrections, &c.—Continued.

Dates.	Stars.	L. p.	Observed time of transit.			Corrections.					Clock-time of meridian transit.			Right ascension.			Clock correct.
						Rate.	Aberration.	Level.	Azimuth.	Collimation.							
1872.			h.	m.	s.	s.	s.	s.	s.	s.	h.	m.	s.	h.	m.	s.	s.
July 25	α Lyræ	E.	18	32	42.67	+0.01	—0.02	—0.05	—0.02	+0.09	18	32	42.68	18	32	38.38	—4.30
July 27	ε Serpentis	W.	15	44	31.75	—.01	—.02	+.02	—.17	—.01	15	44	31.56	15	44	27.57	3.99
	ζ Ursæ Minoris	W.		48	46.72	—.01	—.08	—.01	+.81	—.07		48	47.36		48	43.38	3.98*
	ε Coronæ Borealis	W.		52	22.83	—.01	—.02	—.02	—.08	—.02		52	22.68		52	18.71	3.97
	β¹ Scorpii	W.	15	58	05.68	—.01	—.02	—.01	—.27	—.01	15	58	05.36	15	58	01.35	4.01
	φ Herculis	W.	16	04	49.72	—.01	—.02	—.04	+.02	—.02	16	04	49.65	16	04	45.61	4.04
	δ Ophiuchi	W.		07	44.09	—.01	—.02	—.02	—.20	—.01		07	43.83		07	39.88	3.95
	ε Ophiuchi	W.		11	38.72	—.01	—.02	—.02	—.21	—.01		11	38.45		11	34.51	3.94
	19 Ursæ Minoris	W.		14	36.32	—.01	—.06	—.08	+.66	—.06		14	36.77		14	32.94	3.83*
	A Draconis	W.		28	20.68	—.01	—.04	.00	+.36	—.04		28	20.95		28	16.84	4.11*
	ζ Herculis	E.		36	33.39	—.01	—.02	—.01	—.02	+.02		36	33.35		36	29.30	4.05
	η Herculis	E.		38	36.25	—.01	—.02	—.01	—.01	+.02		38	36.22		38	32.17	4.05
	Groom. 2377	E.		42	58.04	.00	—.03	—.02	+.05	+.03		42	58.07		42	54.21	3.86
	κ Ophiuchi	E.		51	42.37	.00	—.02	.00	—.06	+.01		51	42.30		51	38.26	4.04
	ε Ursæ Minoris	E.	16	59	18.29	.00	—.11	—.01	+.51	+.10	16	59	18.78	16	59	15.21	3.57*
	α¹ Herculis	E.	17	08	54.48	.00	—.02	—.01	—.05	+.01	17	08	54.41	17	08	50.41	4.00
	44 Ophiuchi	E.		18	39.46	.00	—.02	—.01	—.11	+.02		18	39.34		18	35.29	4.05
	Groom. 966, L. C	E.		22	40.18	.00	+.06	+.05	—.37	—.05		22	39.87		22	35.78	4.09*
	β Draconis	E.		27	38.42	.00	—.02	—.06	+.03	+.02		27	38.39		27	34.55	3.84
	ω Draconis	E.		37	48.65	.00	—.04	—.14	+.13	+.04		37	48.64		37	44.97	3.67*
	μ Herculis	E.		41	32.89	.00	—.02	—.07	—.03	+.02		41	32.79		41	28.81	3.98
	ψ¹ Draconis	E.		44	20.19	.00	—.05	—.19	+.18	+.05		44	20.18		44	16.28	3.90*
	γ Draconis	E.	17	53	44.11	+.01	—.03	—.12	+.03	+.02	17	53	44.02	17	53	40.12	3.90
	ο Herculis	E.	18	02	38.92	+.01	—.02	—.07	—.03	+.02	18	02	38.83	18	02	34.90	3.93
	μ¹ Sagittarii	E.		06	12.71	+.01	—.02	—.02	—.10	+.01		06	12.59		06	08.70	3.89
	δ Ursæ Minoris	E.		13	54.84	+.01	—.26	—.45	+1.27	+.24		13	55.65		13	51.48	4.17*
	1 Aquilæ	E.		28	20.54	+.01	—.02	—.01	—0.08	+.01		28	20.45		28	16.59	3.86
	α Lyræ	W.		32	42.44	+.01	—.02	—.11	—.01	—.02		32	42.29		32	38.36	3.93
	51 Cephei, L. C	W.		39	31.08	+.01	+.32	+1.15	—1.29	+.29		39	31.56		39	27.67	3.89*
	β Lyræ	W.		45	27.31	+.01	—.02	—0.10	—0.01	—.02		45	27.17		45	23.29	3.88
	σ Sagittarii	W.		47	26.12	+.01	—.02	—.03	—.08	—.02		47	25.98		47	22.05	3.93
	50 Draconis	W.	18	50	37.50	+.01	—.06	—.29	+.17	—.05	18	50	37.28	18	50	33.71	3.57*
July 28	β Serpentis	E.	15	40	21.94	.00	—.02	+.07	—.21	+.05	15	40	21.83	15	40	18.14	3.69
	ε Serpentis	E.		44	31.43	.00	—.02	+.06	—.27	+.05		44	31.23		44	27.56	3.67
	ζ Ursæ Minoris	E.		48	45.13	.00	—.08	+.24	+1.28	+.25		48	46.82		48	43.28	3.54*
	ε Coronæ Borealis	E.		52	22.32	.00	—.02	+.06	—0.13	+.06		52	22.29		52	18.69	3.60
	β¹ Scorpii	E.	15	58	05.37	.00	—.02	+.02	—.42	+.06	15	58	05.01	15	58	01.34	3.67
	φ Herculis	E.	16	04	49.17	.00	—.02	+.07	+.03	+.07	16	04	49.32	16	04	45.59	3.73
	δ Ophiuchi	E.		07	43.72	.00	—.02	+.03	—.32	+.05		07	43.46		07	39.87	3.59
	ε Ophiuchi	E.		11	38.41	.00	—.02	+.03	—.33	+.05		11	38.14		11	34.50	3.64
	19 Ursæ Minoris	E.		14	35.38	.00	—.06	+.16	+1.04	+.22		14	36.74		14	32.86	3.88*
	η Ursæ Minoris	E.		21	21.43	.00	—.06	+.16	+1.03	+.22		21	22.78		21	19.19	3.59*
	A Draconis	E.		28	19.56	.00	—.04	+.12	+0.56	+.14		28	20.34		28	16.79	3.55*
	ζ Ophiuchi	E.		30	12.24	.00	—.02	+.03	—.36	+.05		30	11.94		30	08.37	3.57
	η Herculis	W.		38	35.82	.00	—.02	+.05	—.02	—.07		38	35.76		38	32.16	3.60
	Groom. 2377	W.		42	57.65	.00	—.03	+.07	+.10	—.10		42	57.69		42	54.18	3.51
	κ Ophiuchi	W.		51	42.06	.00	—.02	+.04	—.12	—.05		51	41.91		51	38.25	3.66
	ε Ursæ Minoris	W.	16	59	17.65	.00	—.11	+.31	+1.05	—.38	16	59	18.52	16	59	15.07	3.45*
	α¹ Herculis	W.	17	08	54.20	.00	—.02	+.04	—0.11	—.05	17	08	54.06	17	08	50.40	3.66
	44 Ophiuchi	W.		18	39.32	.00	—.02	+.01	—.22	—.06		18	39.03		18	35.29	3.74
	Groom. 966, L. C	W.		22	40.17	.00	+.06	—.04	—.76	+.20		22	39.63		22	35.87	3.76*
	β Draconis	W.		27	38.08	.00	—.02	+.03	+.06	—.08		27	38.07		27	34.53	3.54
	ω Draconis	W.		37	48.38	.00	—.04	+.06	+.27	—.14		37	48.53		37	44.93	3.60*
	μ Herculis	W.		41	32.50	.00	—.02	+.03	—.06	—.06		41	32.39		41	28.80	3.59
	ψ¹ Draconis	W.		44	19.66	.00	—.05	+.07	+.36	—.17		44	19.87		44	16.23	3.64*
	γ Draconis	W.	17	53	43.73	.00	—.03	+.05	+.06	—.08	17	53	43.73	17	53	40.11	3.62
	ο Herculis	W.	18	02	38.67	.00	—.02	+.03	—.06	—.06	18	02	38.56	18	02	34.89	3.67
	μ¹ Sagittarii	W.		06	12.61	.00	—.02	+.01	—.21	—.06		06	12.33		06	08.69	3.64
	δ Ursæ Minoris	W.	18	13	53.18	0.00	—0.26	+0.30	+2.62	—0.88	18	13	54.96	18	13	51.21	—3.75*

Computation of observations for clock and instrumental corrections, &c.—Continued.

Date.	Stars.	L. p.	Observed time of transit.			Corrections.					Clock-time of meridian transit.			Right ascension.			Clock correct.
						Rate.	Aberration.	Level.	Azimuth	Collimation.							
1872.			h.	m.	s.	s.	s.	s.	s.	s.	h.	m.	s.	h.	m.	s.	s.
July 28	ψ Draconis	W.	18	23	28.68	.00	−0.05	+0.07	+0.38	−0.18	18	23	28.90	18	23	25.18	−3.72*
	ψ Draconis	E.		23	28.42	.00	− .05	+ .02	+ .37	+ .18		23	28.94		23	25.18	3.76*
	1 Aquilæ	E.		28	20.34	.00	− .02	.00	− .17	+ .05		28	20.20		28	16.59	3.61
	α Lyræ	E.		32	41.95	.00	− .02	+ .01	− .02	+ .07		32	41.99		32	38.36	3.63
	51 Cephei, L. C	E.		39	35.98	.00	+ .32	− .09	−3.51	−1.08		39	31.62		39	27.98	3.64*
	β Lyræ	E.		45	26.90	.00	− .02	+ .01	−0.04	+0.06		45	26.91		45	23.29	3.62
	σ Sagittarii	E.		47	25.86	.00	− .02	.00	− .23	+ .06		47	25.67		47	22.05	3.62
	50 Draconis	E.	18	50	36.55	.00	− .06	+ .02	+ .47	+ .21	18	50	37.19	18	50	33.66	3.53*
July 29	ε Coronæ Borealis	W.	15	52	22.83	+0.02	− .02	− .12	− .10	− .02	15	52	22.57	15	52	18.68	3.89
	φ Herculis	W.	16	04	49.72	+ .02	− .02	− .13	+ .02	− .03	16	04	49.56	16	04	45.56	4.00
	δ Ophiuchi	W.		07	41.06	+ .02	− .02	− .06	− .24	− .02		07	43.72		07	39.86	3.86
	19 Ursæ Minoris	W.		14	36.01	+ .01	− .06	− .24	+ .79	− .09		14	36.41		14	32.77	3.64*
	ω Herculis	W.		19	36.19	+ .01	− .02	− .05	− .16	− .02		19	35.94		19	31.94	4.00
	η Draconis	W.		22	21.21	+ .01	− .03	− .10	+ .24	− .05		22	21.28		22	17.57	3.71
	A Draconis	W.		28	20.21	+ .01	− .04	− .09	+ .42	− .06		28	20.45		28	16.74	3.71*
	ζ Ophiuchi	W.		30	12.61	+ .01	− .01	− .02	− .27	− .02		30	12.28		30	08.36	3.92
	η Herculis	W.		38	36.14	.00	− .02	− .02	− .02	− .03		38	36.05		32	32.14	3.91
	Groom. 2377	W.		42	57.99	.00	− .03	− .03	+ .16	− .04		42	58.05		42	54.15	3.90
	κ Ophiuchi	W.		51	42.40	.00	− .02	− .02	− .19	− .02		51	42.15		51	38.24	3.91
	ε Ursæ Minoris	W.	16	59	17.87	.00	− .11	− .18	+1.61	− .16	16	59	19.03	16	59	14.92	4.11*
	α^1 Herculis	E.	17	08	54.43	.00	− .02	− .02	−0.14	+ .02	17	08	54.27	17	08	50.39	3.88
	44 Ophiuchi	E.		18	39.51	− .01	− .02	− .01	− .30	+ .02		18	39.19		18	35.28	3.91
	β Draconis	E.		27	38.29	− .01	− .03	− .03	+ .08	+ .04		27	38.35		27	34.51	3.84
	ω Draconis	E.		37	48.45	− .02	− .04	− .08	+ .36	+ .06		37	48.75		37	44.89	3.86*
	μ Herculis	E.		41	32.78	− .02	− .02	− .04	− .08	+ .02		41	32.66		41	28.79	3.87
	ψ^1 Draconis	E.		44	19.74	− .02	− .05	− .13	+ .48	+ .07		44	20.11		44	16.18	3.93*
	γ Draconis	E.	17	53	44.18	− .02	− .03	− .08	+ .07	+ .04	17	53	44.16	17	53	40.09	4.07
	ο Herculis	E.	18	02	38.88	− .02	− .02	− .04	− .08	+ .03	18	02	38.75	18	02	34.88	3.87
July 30	β^1 Scorpii	E.	15	58	06.25	+ .09	− .02	− .01	+ .06	+ .04	15	58	06.41	15	58	01.32	5.09
	φ Herculis	E.	16	04	50.55	+ .08	− .02	− .04	.00	+ .03	16	04	50.62	16	04	45.54	5.08
	δ Ophiuchi	E.		07	44.74	+ .08	− .02	− .02	+ .04	+ .04		07	44.86		07	39.85	5.01
	ε Ophiuchi	E.		11	39.42	+ .08	− .02	− .02	+ .04	+ .04		11	39.54		11	34.48	5.06
	19 Ursæ Minoris	E.		14	37.84	+ .07	− .06	− .11	− .14	+ .16		14	37.76		14	32.69	5.07*
	α Scorpii	E.		21	40.33	+ .07	− .02	− .01	+ .06	+ .04		21	40.47		21	35.45	5.02
	β Herculis	E.		24	49.53	+ .07	− .02	− .03	+ .02	+ .04		24	49.61		24	44.59	5.02
	A Draconis	E.		28	21.67	+ .06	− .04	− .10	− .08	+ .11		28	21.62		28	16.69	4.93*
	ζ Ophiuchi	E.	16	30	13.21	+ .06	− .02	− .02	+ .05	+ .04	16	30	13.32	16	30	08.35	4.97
	44 Ophiuchi	W.	17	18	40.07	+ .02	− .02	− .02	+ .29	− .04	17	18	40.30	17	18	35.27	5.03
	β Draconis	W.		27	39.59	+ .02	− .03	− .06	− .08	− .06		27	39.38		27	34.49	4.89
	ω Draconis	W.		37	50.39	+ .01	− .04	− .05	− .36	− .10		37	49.85		37	44.85	5.00*
	μ Herculis	W.		41	33.88	+ .01	− .02	− .02	+ .08	− .04		41	33.89		41	28.78	5.11
	ψ^1 Draconis	W.		44	22.00	.00	− .05	− .05	− .47	− .12		44	21.31		44	16.13	5.18*
	γ Draconis	W.	17	53	45.37	.00	− .03	− .01	− .07	− .06	17	53	45.20	17	53	40.07	5.13
	ο Herculis	W.	18	02	39.92	− .01	− .02	+ .01	+ .08	− .04	18	02	39.94	18	02	34.87	5.07
	μ^1 Sagittarii	W.		06	13.57	− .01	− .02	+ .01	+ .28	− .04		06	13.79		06	08.69	5.10
	η Serpentis	W.		14	48.12	− .02	− .02	+ .01	+ .21	− .01		14	48.26		14	43.21	5.05
	ψ Draconis	W.		23	30.83	− .03	− .05	.01	− .49	− .13		23	30.13		23	25.10	5.03*
	1 Aquilæ	W.		28	21.55	− .03	− .02	− .01	+ .23	− .04		28	21.68		28	16.59	5.09
	α Lyræ	W.		32	43.54	− .03	− .02	− .01	+ .02	− .05		32	43.42		32	38.34	5.08
	ζ Aquilæ	E.	18	59	38.70	− .05	− .02	− .01	+ .11	+ .04	18	59	38.74	18	59	33.64	5.10
	ι Lyræ	E.	19	02	51.32	− .06	− .02	− .05	+ .03	+ .05	19	02	51.27	19	02	46.18	5.09
	δ Draconis	E.		12	39.76	− .07	− .04	− .11	− .26	+ .10		12	39.38		12	34.37	5.01*
	τ Draconis	E.		18	09.57	− .07	− .05	− .14	− .41	+ .13		18	09.03		18	04.02	5.01*
	θ Cygni	E.		33	08.20	− .08	− .03	− .08	− .05	+ .06		33	08.02		33	02.83	5.19
	γ Aquilæ	E.		40	17.70	− .09	− .01	− .05	+ .12	+ .04		40	17.71		40	12.57	5.14
	α Aquilæ	E.		44	39.52	− .09	− .02	− .05	+ .13	+ .04		44	39.53		44	34.41	5.12
	ε Draconis	E.	19	48	44.95	−0.09	−0.04	−0.15	−0.31	+0.11	19	48	44.47	19	48	39.22	−5.25*

Computation of observations for clock and instrumental corrections, &c.—Continued.

Dates.	Stars.	L. p.	Observed time of transit.	Corrections. Rate.	Aberration.	Level.	Azimuth.	Collimation.	Clock-time of meridian transit.	Right ascension.	Clock correct.
1872.			h. m. s.	s.	s.	s.	.	s.	h. m. s.	h. m. s.	s.
Aug. 1	κ Ophiuchi	W.	16 51 46.26	+0.12	−0.02	+0.02	+0.02	−0.06	16 51 46.26	16 51 38.21	−8.13
	ε Ursæ Minoris	W.	16 59 22.84	+ .11	− .12	+ .14	− .20	− .47	16 59 22.30	16 59 14.48	7.82*
	α^1 Herculis	W.	17 08 58.40	+ .10	− .02	+ .03	+ .02	− .07	17 08 58.46	17 08 50.36	8.10
	44 Ophiuchi	W.	18 43.39	+ .09	− .02	+ .02	+ .04	− .07	18 43.45	18 35.26	8.19
	Groom. 966, L. C	W.	22 44.13	+ .08	+ .06	− .07	+ .15	+ .24	22 44.59	22 36.21	8.38*
	β Draconis	W.	27 42.60	+ .07	− .02	+ .07	− .01	− .11	27 42.60	27 34.44	8.16
	ω Draconis	W.	37 53.16	+ .06	− .04	+ .09	− .05	− .18	37 53.04	37 44.76	8.28*
	μ Herculis	W.	41 36.81	+ .06	− .02	+ .03	+ .01	− .07	41 36.82	41 28.76	8.06
	ψ Draconis	W.	44 24.45	+ .05	− .05	+ .07	− .07	− .21	44 24.24	44 16.02	8.22*
	γ Draconis	W.	17 53 48.21	+ .04	− .02	+ .03	− .01	− .10	17 53 48.15	17 53 40.03	8.12
	o Herculis	W.	18 02 43.07	+ .03	− .02	+ .03	+ .01	− .07	18 02 43.05	18 02 34.85	8.20
	μ^1 Sagittarii	W.	06 16.96	+ .03	− .02	+ .01	+ .04	− .07	06 16.95	06 08.68	8.27
	δ Ursæ Minoris	W.	13 59.74	+ .02	− .26	+ .40	− .51	−1.08	13 58.31	13 49.98	8.33*
	ψ Draconis	W.	23 33.63	.00	− .05	+ .10	− .07	−0.22	23 33.39	23 25.01	8.38*
Set I	ψ Draconis	E.	23 33.10	.00	− .05	+ .04	− .07	+ .22	23 33.24	23 25.01	8.23*
	1 Aquilæ	E.	28 24.72	.00	− .02	+ .01	+ .03	+ .07	28 24.81	28 16.58	8.23
	51 Cephei, L. C	E.	39 37.59	− .02	+ .32	− .20	+ .66	−1.33	39 37.02	39 29.43	7.59*
	β Lyræ	E.	45 31.40	− .03	− .02	+ .01	+ .01	+0.08	45 31.54	45 23.26	8.28
	σ Sagittarii	E.	47 30.25	− .03	− .02	.00	+ .04	+ .07	47 30.31	47 22.05	8.26
	ζ Aquilæ	E.	18 59 41.81	− .04	− .02	− .01	+ .02	+ .07	18 59 41.83	18 59 33.64	8.19
	d Sagittarii	E.	19 10 19.27	− .06	− .02	.00	+ .04	+ .07	19 10 19.30	19 10 11.01	8.29
	δ Draconis	E.	12 42.33	− .06	− .04	− .01	− .05	+ .17	12 42.34	12 34.32	8.02*
	τ Draconis	E.	18 11.99	− .07	− .05	.00	− .07	+ .22	18 12.02	18 03.95	8.07*
	β Cygni	E.	25 43.85	− .07	− .02	+ .01	+ .01	+ .07	25 43.85	25 35.67	8.18
	κ Aquilæ	E.	30 10.73	− .08	− .02	+ .01	+ .03	+ .07	30 10.74	30 02.52	8.22
	γ Aquilæ	E.	40 20.80	− .09	− .02	.00	+ .02	+ .07	40 20.78	40 12.58	8.20
	α Aquilæ	E.	44 42.70	− .10	− .02	− .01	+ .02	+ .07	44 42.66	44 34.42	8.24
	ε Draconis	E.	48 47.48	− .10	− .05	− .09	− .06	+ .19	48 47.37	48 39.19	8.18*
	λ Ursæ Minoris	E.	19 53 14.01	− .11	− .83	−2.38	−1.59	+3.41	19 53 12.51	19 53 04.59	7.92*
	θ Aquarii	E.	22 10 15.14	+ .02	− .02	+0.02	+0.09	+0.07	22 10 15.32	22 10 06.85	8.47
	π Aquarii	E.	18 54.80	+ .01	− .01	+ .04	+ .07	+ .06	18 54.97	18 46.45	8.52
Set II	9 Draconis, L. C	E.	24 14.76	.00	+ .07	− .11	+ .41	− .27	24 14.86	24 06.29	8.57*
	η Aquarii	E.	28 57.17	.00	− .02	+ .04	+ .08	+ .06	28 57.33	28 48.75	8.58
	226 Cephei	E.	30 13.63	.00	− .06	+ .18	− .24	+ .26	30 13.77	30 05.17	8.60*
	ζ Pegasi	W.	35 15.13	− .01	− .02	+ .05	+ .06	− .07	35 15.14	35 06.70	8.44
	ι Cephei	W.	22 45 19.21	− .02	− .04	+ .08	− .10	− .15	22 45 18.98	22 45 10.50	8.48*
Aug. 5	A Draconis	W.	16 28 33.95	+ .07	− .04	+ .19	+ .27	− .15	16 28 34.29	16 28 16.37	17.92*
	ζ Ophiuchi	W.	30 26.61	+ .07	− .02	+ .05	− .18	− .05	30 26.48	30 08.28	18.20
	η Herculis	W.	38 50.09	+ .05	− .02	+ .08	− .01	− .07	38 50.12	38 32.01	18.11
	κ Ophiuchi	W.	51 56.47	+ .03	− .02	+ .06	− .12	− .05	51 56.37	51 38.16	18.21
	ε Ursæ Minoris	W.	16 59 31.02	+ .01	− .12	+ .51	+1.04	− .39	16 59 32.07	16 59 13.86	18.21*
	α^1 Herculis	E.	17 09 08.45	.00	− .02	+ .05	−0.12	+ .06	17 09 08.42	17 08 50.31	18.11
	44 Ophiuchi	E.	18 53.65	− .02	− .02	+ .02	− .26	+ .06	18 53.43	18 35.22	18.21
	Groom. 966, L. C	E.	22 55.84	− .02	+ .06	− .10	− .88	− .20	22 54.70	22 36.57	18.13*
	β Draconis	E.	27 52.31	− .03	− .03	+ .09	+ .07	+ .09	27 52.50	27 34.35	18.15
	ω Draconis	E.	38 02.20	− .05	− .04	+ .14	+ .31	+ .15	38 02.71	37 44.57	18.14*
	μ Herculis	E.	41 46.81	− .06	− .02	+ .06	− .07	+ .06	41 46.78	41 28.72	18.06
	ψ^1 Draconis	E.	17 44 33.31	− .06	− .05	+ .16	+ .42	+ .17	17 44 33.95	17 44 15.80	18.15*
Aug. 6	η Draconis	E.	16 22 37.45	+ .20	− .03	+ .07	+ .23	+ .10	16 22 38.02	16 22 17.26	20.76
	A Draconis	E.	28 36.23	+ .19	− .04	+ .11	+ .41	+ .13	28 37.03	28 16.31	20.72*
	ζ Ophiuchi	E.	30 29.18	+ .19	− .02	+ .03	− .26	+ .05	30 29.17	30 08.27	20.90
	ζ Herculis	E.	36 49.80	+ .17	− .02	+ .07	− .07	+ .06	36 50.01	36 29.14	20.87
	η Herculis	E.	38 52.53	+ .17	− .02	+ .08	− .02	+ .06	38 52.80	38 31.99	20.81
	κ Ophiuchi	E.	51 58.98	+ .15	− .02	+ .06	− .18	+ .05	51 59.04	51 38.15	20.89
	ε Ursæ Minoris	E.	16 59 32.34	+ .13	− .11	+ .36	+1.54	+ .35	16 59 34.61	16 59 13.71	20.90*
	α^1 Herculis	W.	17 09 11.12	+ .11	− .01	− .03	−0.04	− .05	17 09 11.10	17 08 50.30	20.80
	44 Ophiuchi	W	18 56.34	+ .09	− .02	− .01	− .08	− .05	18 56.27	18 35.21	21.06
	β Draconis	W.	27 54.85	+ .08	− .02	+ .02	+ .02	− .08	27 54.87	27 34.32	20.55
	ω Draconis	W.	17 38 04.96	+0.06	−0.04	+0.07	+0.10	−0.13	17 38 05.02	17 37 44.52	−20.50*

Computation of observations for clock and instrumental corrections, &c.—Continued.

Dates.	Stars.	L. p.	Observed time of transit.			Corrections.					Clock-time of meridian transit.			Right ascension.			Clock correct.
						Rate.	Aberration.	Level.	Azimuth.	Collimation.							
1872.			h.	m.	s.	s.	s.	s.	s.	s.	h.	m.	s.	h.	m.	s.	s.
Aug. 6	μ Herculis	W.	17	41	49.64	+0.05	—0.02	+0.04	—0.03	—0.05	17	41	49.63	17	41	28.71	—20.92
	ψ¹ Draconis	W.		44	36.38	+ .04	— .05	+ .10	+ .14	— .15		44	36.46		44	15.74	20.72*
	γ Draconis	W.	17	54	00.70	+ .03	— .02	+ .07	+ .02	— .08	17	54	00.72	17	53	39.93	20.79
	o Herculis	W.	18	02	55.73	+ .01	— .02	+ .05	— .02	— .05	18	02	55.70	18	02	34.80	20.90
	μ¹ Sagittarii	W.		06	29.76	+ .01	— .02	+ .02	— .08	— .05		06	29.64		06	08.64	21.00
	δ Ursæ Minoris	W.		14	08.97	— .01	— .26	+ .50	+ .99	— .80		14	09.39		13	48.47	20.92*
	ψ Draconis	W.		23	45.58	— .03	— .05	+ .12	+ .14	— .16		23	45.60		23	24.76	20.84*
	ψ Draconis	E.		23	45.22	— .03	— .05	+ .09	+ .35	+ .16		23	45.74		23	24.76	20.98*
	1 Aquilæ	E.		28	37.58	— .04	— .02	+ .02	— .16	+ .05		28	37.43		28	16.56	20.87
	α Lyræ	E.		32	59.08	— .05	— .02	+ .04	— .02	+ .06		32	59.09		32	38.27	20.82
	ζ Aquilæ	E.	18	59	54.67	— .10	— .02	+ .01	— .10	+ .05	18	59	54.51	18	59	33.62	20.89
	ι Lyræ	E.	19	03	07.06	— .10	— .02	+ .01	— .03	+ .06	19	03	06.98	19	02	46.14	20.84
	d Sagittarii	E.		10	32.20	— .12	— .02	.00	— .19	+ .05		10	31.92		10	11.01	20.91
	δ Draconis	E.		12	54.78	— .12	— .04	+ .01	+ .23	+ .12		12	54.98		12	34.19	20.79*
	τ Draconis	E.		18	24.12	— .13	— .05	+ .01	+ .36	+ .16		18	24.47		18	03.76	20.71*
	β¹ Cygni	E.		25	56.63	— .14	— .02	.00	— .06	+ .05		25	56.46		25	35.66	20.80
	κ Aquilæ	E.		30	23.61	— .15	— .02	.00	— .16	+ .05		30	23.33		30	02.53	20.80
	γ Aquilæ	E.		40	33.60	— .17	— .02	.00	— .11	+ .05		40	33.35		40	12.58	20.77
	α Aquilæ	E.		44	55.54	— .18	— .02	.00	— .11	+ .05		44	55.28		44	34.42	20.86
	ε Draconis	E.	19	48	59.80	— .19	— .05	.00	+ .27	+ .14	19	48	59.97	19	48	39.07	20.90*
Aug. 7	A Draconis	W.	16	28	39.36	+ .19	— .04	— .12	+ .46	— .12	16	28	39.73	16	28	16.26	23.47*
	ζ Ophiuchi	W.		30	32.25	+ .18	— .02	— .03	— .29	— .04		30	32.05		30	08.26	23.79
	η Herculis	W.		38	55.59	+ .17	— .02	— .02	— .03	— .05		38	55.64		38	31.97	23.67
	κ Ophiuchi	W.		52	02.03	+ .14	— .02	+ .01	— .20	— .04		52	01.92		51	38.14	23.78
	ε Ursæ Minoris	W.	16	59	35.84	+ .12	— .12	+ .10	+1.73	— .32	16	59	37.35	16	59	13.55	23.80*
	α¹ Herculis	W.	17	09	14.13	+ .10	— .02	+ .01	—0.17	— .04	17	09	14.01	17	08	50.29	23.72
	44 Ophiuchi	W.		18	59.36	+ .08	— .02	.00	— .36	— .05		18	59.01		18	35.20	23.81
	Groom. 966, L. C	W.		23	01.60	+ .08	+ .06	— .02	—1.25	+ .17		23	00.64		22	36.75	23.89*
	β Draconis	W.		27	57.83	+ .07	— .02	+ .01	+0.10	— .07		27	57.92		27	34.30	23.62
	ω Draconis	W.		38	08.06	+ .04	— .04	+ .02	+ .45	— .12		38	08.41		37	44.47	23.94*
	μ Herculis	W.		41	52.53	+ .04	— .02	+ .01	— .10	— .05		41	52.41		41	28.69	23.72
	ψ¹ Draconis	W.		44	39.25	+ .03	— .05	+ .03	+ .59	— .14		44	39.71		44	15.68	24.03*
	γ Draconis	W.	17	54	03.69	+ .01	— .02	+ .01	+ .09	— .07	17	54	03.71	17	53	39.90	23.81
	o Herculis	E.	18	02	58.61	— .01	— .02	.00	— .05	+ .05	18	02	58.58	18	02	34.79	23.79
	μ¹ Sagittarii	E.		06	32.72	— .01	— .02	.00	— .17	+ .04		06	32.56		06	08.64	23.92
	δ Ursæ Minoris	E.		14	09.16	— .03	— .26	+ .28	+2.10	+ .73		14	11.98		13	48.19	23.79*
	1 Aquilæ	E.		28	40.56	— .06	— .02	+ .01	—0.14	+ .04		28	40.39		28	16.56	23.83
	α Lyræ	E.		33	02.09	— .07	— .02	+ .01	— .01	+ .05		33	02.05		32	38.25	23.80
	51 Cephei, L. C	E.		39	58.70	— .08	+ .32	+ .01	—2.84	— .89		39	55.22		39	31.52	23.70*
	β Lyræ	E.		45	47.15	— .09	— .02	— .02	—0.03	+ .05		45	47.04		45	23.22	23.82
	σ Sagittarii	E.		47	46.12	— .10	— .02	— .01	— .18	+ .05		47	45.86		47	22.03	23.83
	13 Lyræ	E.		51	52.28	— .11	— .02	— .05	+ .01	+ .06		51	52.17		51	28.47	23.70
	ε Aquilæ	E.		54	14.71	— .11	— .02	— .04	— .08	+ .04		54	14.50		53	50.79	23.71
	ζ Aquilæ	E.	18	59	57.57	— .12	— .02	— .05	— .09	+ .04	18	59	57.33	18	59	33.61	23.72
	d Sagittarii	E.	19	10	35.16	— .15	— .02	— .03	— .17	+ .05	19	10	34.84	19	10	11.01	23.83
	δ Draconis	E.		12	57.74	— .15	— .04	— .15	+ .20	+ .11		12	57.71		12	34.16	23.55*
	τ Draconis	E.	19	18	27.03	— .16	— .05	— .18	+ .31	+ .15	19	18	27.10	19	18	03.72	23.38*
Aug. 9	κ Ophiuchi	W.	16	52	07.46	+ .13	— .01	— .04	— .08	— .03	16	52	07.43	16	51	38.12	29.31
	ε Ursæ Minoris	W.	16	59	41.76	+ .12	— .11	— .21	+ .73	— .21		59	42.08	16	59	13.23	28.85*
	α¹ Herculis	W.	17	09	19.54	+ .10	— .02	— .06	— .07	— .03	17	09	19.46	17	08	50.27	29.19
	44 Ophiuchi	W.		19	04.62	+ .09	— .02	— .03	— .16	— .03		19	04.47		18	35.18	29.29
	Groom. 966, L. C	W.		23	06.70	+ .08	+ .06	+ .14	— .53	+ .11		23	06.56		22	36.94	29.62*
Set I	α Ophiuchi	W.		29	30.61	+ .07	— .02	— .07	— .08	— .03		29	30.48		29	01.28	29.20
	ω Draconis	W.		38	13.59	+ .06	— .04	— .18	+ .19	— .08		38	13.54		37	44.37	29.17*
	μ¹ Herculis	W.		41	57.89	+ .05	— .02	— .07	— .05	— .03		41	57.77		41	28.67	29.10
	ψ¹ Draconis	W.		44	44.74	+ .04	— .05	— .17	+ .25	— .09		44	44.72		44	15.56	29.16*
	γ Draconis	W.	17	54	09.17	+ .03	— .02	— .07	+ .04	— .05	17	54	09.10	17	53	39.86	29.24
	o Herculis	W.	18	03	04.11	+ .01	— .02	— .05	— .04	— .03	18	03	03.98	18	02	34.77	29.21
	μ¹ Sagittarii	W.	18	06	38.05	+0.01	—0.02	—0.02	—0.15	—0.03	18	06	37.84	18	06	08.62	—29.22

Computation of observations for clock and instrumental corrections, &c.—Continued.

Dates.	Stars.	L. p.	Observed time of transit.	Corrections. Rate.	Aberration.	Level.	Azimuth.	Collimation.	Clock-time of meridian transit.	Right ascension.	Clock correct.
1872.			h. m. s.	s.	s.	s.	s.	s.	h. m. s.	h. m. s.	s.
Aug. 9	δ Ursæ Minoris	W.	18 14 16.70	.00	−0.26	−0.67	+1.81	−0.47	18 14 17.11	18 13 47.61	−29.50*
	ψ Draconis	W.	23 54.12	−0.02	−.05	−.16	+0.26	−.09	23 54.06	23 24.59	29.47*
	ψ Draconis	E.	23 53.94	−.02	−.05	−.07	+.16	+.09	23 54.05	23 24.59	29.46*
	α Lyræ	E.	33 07.56	−.04	−.02	−.03	−.01	+.04	33 07.50	32 38.23	29.27
	51 Cephei, L. C	E.	40 02.94	−.05	+.32	+.33	−1.50	−.58	40 01.46	39 32.18	29.28*
	β Lyræ	E.	45 52.56	−.06	−.02	−.05	−0.02	+.03	45 52.44	45 23.20	29.24
Set I.	σ Sagittarii	E.	47 51.38	−.06	−.02	−.02	−.10	+.03	47 51.21	47 22.03	29.18
	13 Lyræ	E.	51 57.83	−.07	−.02	−.08	.00	+.04	51 57.70	51 28.44	29.26
	ε Aquilæ	E.	18 54 20.15	−.07	−.02	−.06	−.04	+.03	18 54 19.99	53 50.78	29.21
	ζ Aquilæ	E.	19 00 02.98	−.08	−.02	−.07	−.05	+.03	19 00 02.79	18 59 33.60	29.19
	d Sagittarii	E.	10 40.41	−.10	−.02	−.04	−.09	+.03	10 40.19	19 10 11.01	29.18
	δ Draconis	E.	13 03.50	−.10	−.04	−.20	+.10	+.07	13 03.33	12 34.10	29.23
	τ Draconis	E.	19 18 33.06	−.11	−.05	−.23	+.16	+.10	19 18 32.93	19 18 03.64	29.29*
	α Pegasi	E.	22 58 51.99	+.06	−.02	−.04	.00	+.03	22 58 55.05	22 58 25.23	29.79
	ο Cephei	E.	23 13 55.62	+.04	−.04	−.09	+.01	+.07	23 13 55.61	23 13 25.74	29.87*
	θ Piscium	E.	22 00.31	+.02	−.02	−.03	.00	+.03	22 00.31	21 30.57	29.74
Set II	ι Piscium	E.	33 53.88	.00	−.02	−.03	.00	+.03	33 53.86	33 24.05	29.81
	Groom. 4163	E.	23 49 11.17	−.02	−.06	−.15	+.01	+.10	23 49 11.05	23 48 41.32	29.73*
	α Andromedæ	E.	0 02 18.25	−.05	−.02	−.05	.00	+.03	0 02 18.16	0 01 48.38	29.78
	γ Pegasi	E.	0 07 10.48	−0.05	−0.02	−0.04	0.00	+0.03	0 07 10.40	0 06 40.62	−29.78

Cambridge clock-corrections, deduced from stars of less than 65° N. declination.

Date.	T_o	Number of time-stars.	ΔT_o
1872.	h. m.		s.
July 19	17 39	8	−5.191
20	17 37	17	5.017
21	17 49	4	4.857
22	17 21	14	4.657
23	16 42	1	4.391
24	17 43	18	4.179
25	16 40	17	4.191
27	17 16	21	3.957
28	17 15	22	3.635
29	16 55	15	3.908
30	17 50	21	5.069
August 1	18 26	17	8.197
1	22 27	4	8.502
5	17 9	7	18.152
6	18 9	21	20.848
7	18 0	18	23.772
9	18 11	15	29.220
9	23 35	5	−29.780

NOTE.—The slight differences between the mean clock-corrections given in this table and those derived from the computations as here published, are due to the fact that in the original computation, from which this table is formed, the clock-correction resulting from each star is given to the thousandth place.

Computation of observations for clock and instrumental corrections at St. Pierre, Miquelon, 1872.

(Observer, Edward Goodfellow.—An asterisk is affixed to the clock-corrections derived from stars of more than 65° N. declination.

Dates.	Stars.	L. p.	Observed time of transit.			Corrections. Rate.	Aberration.	Level.	Azimuth.	Collimation.	Clock-time of meridian transit.			Right ascension.			Clock correct.
1872.			h.	m.	s.	s.	s.	s.	s.	s.	h.	m.	s.	h.	m.	s.	s.
July 9	β Ursæ Minoris......	E.	14	51	38.58	−0.03	−0.05	+0.04	+1.03	−0.11	14	51	39.46	14	51	08.85	−30.61*
	β Bootis	E.	14	57	39.56	−.03	−.02	+.02	−.08	−.04	14	57	39.41	14	57	08.85	30.56
	β Libræ	E.	15	10	39.80	−.01	−.02	+.01	−.49	−.03	15	10	39.26	15	10	08.62	30.64
	γ^{2} Ursæ Minoris......	E.		21	29.57	.00	−.04	+.07	+.82	−.10		21	30.32		20	59.67	30.65*
Set I...	γ^{2} Ursæ Minoris......	W.		21	29.47	.00	−.05	−.10	−1.05	+.10		21	30.47		20	59.67	30.80*
	α Coronæ Borealis ...	W.		29	48.54	+.01	−.02	−.01	−0.28	+.03		29	48.24		29	17.61	30.63
	α Serpentis	W.		38	30.38	+.01	−.01	−.03	−.48	+.03		38	29.90		37	59.33	30.57
	β Serpentis	W.		40	49.39	+.02	−.02	−.03	−.40	+.03		40	48.99		40	18.34	30.65
	ζ Ursæ Minoris......	W.		49	13.74	+.02	−.07	−.13	+1.88	+.15		49	15.59		48	45.08	30.51*
	δ Scorpii............	W.	15	53	19.08	+.03	−.01	−.01	−0.75	+.03	15	53	18.37	15	52	47.78	30.59
	ν Ophiuchi..........	W.	17	52	32.18	−.04	−.01	−.01	−.88	+.02	17	52	31.26	17	52	00.84	30.42
	γ Draconis..........	W.	17	54	10.88	−.04	−.02	−.03	+.14	+.03	17	54	10.96	17	53	40.35	30.61
	o Herculis..........	W.	18	03	05.84	−.03	−.02	−.01	−.37	+.02	18	03	05.43	18	02	34.96	30.47
	μ^{1} Sagittarii	W.		06	40.16	−.03	−.02	.00	−1.03	+.02		06	39.10		06	08.67	30.43
	η Serpentis	W.		15	14.41	−.02	−.01	.00	−0.79	+.02		15	13.59		14	43.20	30.39
	δ Ursæ Minoris......	W.		14	14.59	−.02	−.24	−.15	+11.21	+.34		14	25.73		13	55.28	30.45*
	1 Aquilæ	E.		28	47.89	−.01	−.01	+.01	−0.92	−.02		28	46.94		28	16.54	30.40
Set II..	Vega	E.		33	09.04	.00	−.02	+.03	−.20	−.03		33	08.82		32	38.42	30.40
	110 Herculis..........	E.		40	42.35	.00	−.01	+.02	−.53	−.02		40	41.81		40	11.25	30.56
	β Lyræ	E.		45	54.09	+.01	−.02	+.03	−.31	−.02		45	53.78		45	23.30	30.48
	50 Draconis..........	E.		51	02.68	+.02	−.06	+.08	+2.08	−.08		51	04.72		50	34.26	30.46*
	50 Draconis..........	W.	18	51	02.64	+.02	−.06	−.19	+2.25	+.08	18	51	04.74		50	34.26	30.48*
	ζ Aquilæ	W.	19	00	04.73	+.02	−.01	−.04	−0.67	+.02	19	00	04.05	18	59	33.57	30.48
	δ Draconis..........	W.		13	04.19	+.04	−.01	−.06	+1.10	+.05		13	05.28	19	12	34.63	30.65*
	τ Draconis..........	W.		18	32.93	+.04	−.05	−.07	+1.83	+.07		18	34.75		18	04.41	30.34*
	τ Draconis..........	E.	19	18	33.36	+.04	−.05	+.18	+1.83	−.07	19	18	35.29	19	18	04.41	30.88*
July 10	ε Bootis	E.	14	39	54.02	−.03	−.01	+.07	+0.08	−.04	14	39	54.09	14	39	25.04	29.05
	β Ursæ Minoris......	E.	14	51	38.35	−.01	−.05	+.20	−.38	−.14	14	51	37.95	14	51	08.78	29.17*
	β Libræ............	E.	15	10	37.62	.00	−.01	+.02	+.18	−.04	15	10	37.77	15	10	08.61	29.16
	γ^{2} Ursæ Minoris......	E.		21	29.08	+.01	−.05	+.07	−.31	−.12		21	28.68		20	59.61	29.07*
	γ^{2} Ursæ Minoris......	W.		21	29.11	+.01	−.05	−.01	−.40	+.12		21	28.75		20	59.61	29.14*
	α Coronæ Borealis ...	W.	15	29	46.64	+.02	−.02	−.01	+.11	+.01	15	29	46.78	15	29	17.60	29.18
July 12	ε Bootis	W.	14	39	51.08	−.03	−.01	+.01	+.11	+.07	14	39	51.23	14	39	25.01	26.22
	β Ursæ Minoris......	W.	14	51	35.36	−.02	−.06	+.04	−.52	+.23	14	51	35.03	14	51	08.64	26.39*
	β Libræ............	W.	15	10	34.69	.00	−.02	+.01	+.25	+.06	15	10	34.99	15	10	08.60	26.39
	γ^{2} Ursæ Minoris......	W.		21	25.94	+.01	−.05	+.05	−.42	+.20		21	25.73		20	59.50	26.23*
	γ^{2} Ursæ Minoris......	E.		21	26.21	+.01	−.05	+.22	−.37	−.20		21	25.82		20	59.50	26.32*
	α Coronæ Borealis ...	E.		29	43.72	+.02	−.02	+.07	+.10	−.07		29	43.82		29	17.58	26.24
	α Serpentis	E.	15	38	25.52	+.02	−.01	+.05	+.17	−.06	15	38	25.69	15	37	59.31	26.38
July 14	β Ursæ Minoris......	W.	14	51	32.58	−.05	−.05	+.14	−.61	+.14	14	51	32.15	14	51	08.50	23.65*
	β Bootis	W.	14	57	32.24	−.04	−.02	+.05	+.05	+.05	14	57	32.33	14	57	08.77	23.56
	β Libræ............	W.	15	10	31.94	−.03	−.02	+.02	+.29	+.04	15	10	32.24	15	10	08.58	23.66
	γ^{2} Ursæ Minoris......	W.		21	23.32	−.02	−.04	+.08	−.49	+.12		21	22.97		20	59.38	23.59*
	γ^{2} Ursæ Minoris......	E.		21	23.39	−.02	−.05	+.23	−.27	−.12		21	23.16		20	59.38	23.78*
	α Coronæ Borealis ...	E.		29	40.95	−.01	−.02	+.08	+.07	−.04		29	41.03		29	17.55	23.48
	α Serpentis	E.		38	22.74	.00	−.01	+.05	+.12	−.04		38	22.86		37	59.29	23.57
Set I...	β Serpentis	E.		40	41.76	.00	−.01	+.05	+.10	−.04		40	41.86		40	18.30	23.56
	ζ Ursæ Minoris......	E.		49	08.65	+.01	−.07	+.23	−.49	−.18		49	08.15		48	44.64	23.51*
	δ Scorpii............	E.		53	11.26	+.01	−.01	+.02	+.19	−.04		53	11.43		52	47.75	23.68
	β^{1} Scorpii............	E.	15	58	24.98	+.02	−.02	+.02	+.19	−.04	15	58	25.15	15	58	01.47	23.68
	Groom. 2320	E.	16	06	25.32	+.02	−.04	+.14	−.19	−.10	16	06	25.15	16	06	01.47	23.68*
	19 Ursæ Minoris......	W.		14	57.68	+.03	−.06	+.04	−.22	+.15		14	57.62		14	33.96	23.66*
	ω Herculis..........	W.		19	55.62	+.04	−.02	+.01	+.06	+.04		19	55.75		19	32.08	23.67
	η Draconis..........	W.	16	22	41.54	+.04	−0.03	+0.02	−0.06	+0.08	16	22	41.59	16	22	18.08	−23.51

Computation of observations for clock and instrumental corrections, &c.—Continued.

Dates.	Stars.	L. p.	Observed time of transit.			Corrections. Rate.	Aberration.	Level.	Azimuth.	Collimation.	Clock-time of meridian transit.			Right ascension.			Clock correct.
1872.			h.	m.	s.	s.	s.	s.	s.	s.	h.	m.	s.	h.	m.	s.	s.
July 14	ψ^1 Draconis	W.	17	44	40.41	−0.04	−0.05	−0.03	+0.25	+0.04	17	44	40.58	17	44	16.83	−23.75*
	γ Draconis	W.	17	54	03.94	−.03	−.02	+.01	+.02	+.02	17	54	03.94	17	53	40.31	23.63
	o Herculis	W.	18	02	58.45	−.02	−.01	+.02	−.06	+.01	18	02	58.39	18	02	34.95	23.44
	μ^1 Sagittarii	W.		06	32.32	−.02	−.01	+.01	−.17	+.01		06	32.14		06	08.69	23.45
	δ Ursæ Minoris	W.		14	15.99	−.01	−.24	+.19	+1.88	+.20		14	18.01		13	54.50	23.51*
	δ Ursæ Minoris	E.		14	16.86	−.01	−.24	+1.02	+0.64	−.20		14	18.07		13	54.50	23.57*
Set II..	b Draconis	E.		22	28.57	.00	−.03	+0.15	+.02	−.02		22	28.69		22	04.96	23.73
	1 Aquilæ	E.		28	40.17	.00	−.02	+.05	−.05	−.01		28	40.14		28	16.57	23.57
	Vega	E.		33	01.84	+.01	−.02	+.11	−.01	−.02		33	01.91		32	38.42	23.49
	β Lyræ	E.		45	46.76	+.02	−.02	+.10	−.02	−.01		45	46.83		45	23.31	23.52
	50 Draconis	E.		50	57.22	+.02	−.05	+.29	+.11	−.05		50	57.54		50	34.15	23.39*
	50 Draconis	W.		50	57.35	+.02	−.06	+.10	+.27	+.05		50	57.73		50	34.15	23.58*
	ζ Aquilæ	W.	18	59	57.15	+.03	−.01	+.03	−.08	+.01	18	59	57.13	18	59	33.60	23.53
	d Sagittarii	W.	19	10	34.64	+.04	−.01	+.01	−.14	+.01	19	10	34.55	19	10	10.93	23.62
July 17	β Libræ	E.	15	10	28.40	−.04	−.01	+.01	+.10	−.10	15	10	28.36	15	10	08.55	19.81
	γ^2 Ursæ Minoris	E.		21	19.48	−.03	−.05	+.07	−.16	−.33		21	18.98		20	59.20	19.78*
	γ^2 Ursæ Minoris	W.		21	18.92	−.03	−.05	−.10	+.06	+.33		21	19.13		20	59.20	19.93*
	α Coronæ Borealis	W.		29	37.15	−.02	−.02	−.03	−.01	+.11		29	37.18		29	17.52	19.66
	α Serpentis	W.		38	18.95	−.01	−.01	−.02	−.03	+.10		38	18.98		37	59.27	19.71
	β Serpentis	W.		40	37.94	−.01	−.01	−.02	−.02	+.10		40	37.98		40	18.27	19.71
	ζ Ursæ Minoris	W.		49	03.57	.00	−.07	−.11	+.10	+.49		49	03.98		48	44.36	19.62*
Set I...	δ Scorpii	W.		53	07.47	.00	−.02	−.01	−.04	+.11		53	07.51		52	47.72	19.79
	β^1 Scorpii	W.	15	58	21.16	.00	−.01	−.02	−.04	+.11	15	58	21.20	15	58	01.45	19.75
	Groom. 2320	W.	16	06	20.94	+.01	−.04	−.13	+.04	+.27	16	06	21.09	16	06	01.34	19.75*
	ε Ophiuchi	E.		11	54.54	+.02	−.01	+.01	−.13	−.10		11	54.33		11	34.59	19.74
	τ Herculis	E.		16	15.31	+.02	−.02	+.02	.00	−.15		16	15.18		15	55.48	19.70
	A Draconis	E.		28	37.11	+.03	−.04	+.06	+.17	−.28		28	37.05		28	17.32	19.73*
	η Herculis	E.	16	38	52.11	+.04	−.02	+.04	−.03	−.13	16	38	52.01	16	38	32.33	19.68
July 17	δ Ursæ Minoris	E.	18	14	10.48	−.02	−.24	+.14	+5.25	−2.03	18	14	13.58	18	13	53.82	19.76*
	μ^1 Sagittarii	E.		06	29.11	−.03	−.02	.00	−0.48	−.13		06	28.45		06	08.70	19.75
	b Draconis	E.		22	24.85	−.02	−.03	+.02	+.19	−.23		22	24.78		22	04.92	19.86
	1 Aquilæ	E.		28	36.90	−.02	−.01	+.01	−.40	−.12		28	36.36		28	16.57	19.79
	Vega	E.		32	58.21	−.01	−.02	+.04	−.09	−.15		32	57.98		32	38.42	19.56
	β Lyræ	E.		45	43.32	.00	−.02	+.05	−.14	−.14		45	43.07		45	23.32	19.75
Set II..	50 Draconis	E.		50	53.01	+.01	−.06	+.14	+.91	−.47		50	53.54		50	34.07	19.47*
	50 Draconis	W.		50	52.49	+.01	−.06	−.11	+1.10	+.47		50	53.90		50	34.07	19.83*
	ε Aquilæ	W.		54	10.74	+.01	−.01	−.03	−0.32	+.12		54	10.51		53	50.81	19.70
	ζ Aquilæ	W.	18	59	53.54	+.01	−.01	−.03	−.33	+.12	18	59	53.30	18	59	33.62	19.68
	d Sagittarii	W.	19	10	31.18	+.02	−.01	−.02	−.57	+.13	19	10	30.73	19	10	10.96	19.77
	τ Draconis	W.	19	18	22.75	+.03	−.05	−.13	+.89	+.41	19	18	23.90	19	18	04.32	19.58*
July 18	γ^2 Ursæ Minoris	E.	15	21	18.20	−.03	−.05	−.08	−.24	−.08	15	21	17.72	15	20	59.13	18.59*
	α Coronæ Borealis	E.		29	35.96	−.02	−.01	−.03	+.06	−.03		29	35.93		29	17.50	18.43
	α Serpentis	E.		38	17.74	−.02	−.01	−.02	+.11	−.02		38	17.78		37	59.26	18.52
	β^1 Serpentis	E.		40	36.70	−.02	−.01	−.02	+.09	−.02		40	36.72		40	18.26	18.46
	ζ Ursæ Minoris	E.		49	03.37	−.01	−.07	−.06	−.43	−.11		49	02.69		48	44.27	18.42*
	ζ Ursæ Minoris	W.		49	03.46	−.01	−.07	−.25	−.52	+.11		49	02.72		48	44.27	18.45*
	δ Scorpii	W.		53	05.99	.00	−.02	−.02	+.21	+.02		53	06.18		52	47.71	18.47
	β^1 Scorpii	W.	15	58	19.72	.00	−.01	−.03	+.20	+.02	15	58	19.90	15	58	01.44	18.46
	Groom. 2320	W.	16	06	20.22	+.01	−.04	−.15	−.20	+.06	16	06	19.90	16	06	01.30	18.60*
	ε Ophiuchi	W.		11	52.98	+.01	−.01	−.04	+.16	+.02		11	53.12		11	34.59	18.53
	τ Herculis	W.		16	13.98	+.01	−.02	−.08	.00	+.03		16	13.92		15	55.46	18.46
	η Draconis	W.		22	36.57	+.02	−.03	−.12	−.11	+.05		22	36.38		22	17.95	18.43
	A Draconis	E.		28	35.96	+.03	−.04	+.08	−.20	−.06		28	35.77		28	17.28	18.49*
	η Herculis	E.	16	38	50.77	+.04	−.02	+.03	+.03	−.03	16	38	50.80	16	38	32.31	18.49
July 20	α Delphini	E.	20	33	59.27	−.02	−.01	+.02	+.04	+.04	20	33	59.34	20	33	43.61	15.73
	α Cygni	E.		37	21.91	−.01	−.02	+.03	.00	+.06		37	21.97		37	06.34	15.63
	μ Aquarii	E.		46	02.79	−.01	−.01	+.01	+.07	+.04		46	02.89		45	47.10	15.79
	12 Y. C. 1879	E.	20	53	40.96	0.00	−0.08	+0.11	−0.26	+0.24	20	53	40.97	20	53	25.22	−15.75*

Computation of observations for clock and instrumental corrections, &c.—Continued.

Dates.	Stars.	L. p.	Observed time of transit.			Corrections. Rate.	Aberration.	Level.	Azimuth.	Collimation.	Clock-time of meridian transit.			Right ascension.			Clock correct.
1872.			h.	m.	s.	s.	s.	s.	s.	s.	h.	m.	s.	h.	m.	s.	s.
July 20	12 Y. C., 1879	W.	20	53	41.50	0.00	—0.08	—0.10	—0.07	—0.24	20	53	41.01	20	53	25.22	—15.79*
	σ^2 Ursæ Majoris, L. C	W.	20	59	19.82	.00	+ .04	+ .02	+ .05	+ .11	20	59	20.04	20	59	04.23	15.81*
	ξ Cygni	W.	21	07	47.09	+ .01	— .02	— .03	+ .01	— .05	21	07	47.01	21	07	31.33	15.68
	α Cephei	W.	21	15	49.89	+ .02	— .03	— .07	— .01	— .09	21	15	49.71	21	15	34.04	15.67
July 21	γ^2 Ursæ Minoris	E.	15	21	13.96	— .04	— .05	— .06	— .18	+ .06	15	21	13.69	15	20	58.95	14.74*
	α Coronæ Borealis	E.		29	31.98	— .03	— .02	— .02	+ .05	+ .02		29	31.98		29	17.46	14.52
	α Serpentis	E.		38	13.71	— .02	— .01	— .01	+ .08	+ .02		38	13.77		37	59.23	14.54
	β Serpentis	E.		40	32.76	— .02	— .02	.00	+ .07	+ .02		40	32.81		40	18.23	14.58
	ζ Ursæ Minoris	E.		48	58.74	— .01	— .07	.00	— .32	+ .09		48	58.43		48	43.98	14.45*
	ζ Ursæ Minoris	W.		48	59.19	— .01	— .07	— .23	— .13	— .09		48	58.66		48	43.98	14.68*
	δ Scorpii	W.		53	02.30	— .01	— .02	— .02	+ .05	— .02		53	02.28		52	47.68	14.60
Set I	β^1 Scorpii	W.	15	58	16.02	.00	— .01	— .03	+ .05	— .02	15	58	16.01	15	58	01.41	14.60
	Groom. 2320	W.	16	06	16.19	.00	— .04	— .20	— .05	— .05	16	06	15.85	16	06	01.16	14.69*
	τ Herculis	W.		16	10.16	+ .01	— .02	— .12	.00	— .03		16	10.00		15	55.40	14.60
	η Draconis	W.		22	32.49	+ .02	— .03	— .15	— .03	— .04		22	32.26		22	17.86	14.40
	A Draconis	W.		28	31.72	+ .02	— .04	— .16	— .05	— .05		28	31.44		28	17.14	14.30*
	η Herculis	E.		38	46.75	+ .03	— .02	+ .01	+ .01	+ .02		38	46.80		38	32.27	14.53
	κ Ophiuchi	E.	16	51	53.00	+ .04	— .01	.00	+ .03	+ .02	16	51	53.08	16	51	38.31	14.77
July 21.	β Lyræ	E.	18	45	37.95	— .03	— .02	.00	— .14	.00	18	45	37.76	18	45	23.32	14.44
	50 Draconis	E.		50	47.71	— .03	— .06	.00	+ .96	.00		50	48.58		50	33.94	14.64*
	ε Aquilæ	E.		54	05.58	— .02	— .01	.00	— .28	.00		54	05.27		53	50.83	14.44
	ζ Aquilæ	E.	18	59	48.38	— .02	— .01	.00	— .29	.00	18	59	48.06	18	59	33.64	14.42
	d Sagittarii	E.	19	10	26.12	— .01	— .01	.00	— .49	.00	19	10	25.61	19	10	10.98	14.63
	δ Draconis	E.		12	48.39	— .01	— .04	— .01	+ .47	.00		12	48.80		12	34.53	14.27*
	τ Draconis	E.		18	17.99	.00	— .05	— .02	+ .78	.00		18	18.70		18	04.25	14.45*
Set II	τ Draconis	W.		18	17.86	.00	— .05	— .08	+ .88	.00		18	18.61		18	04.25	14.36*
	β^1 Cygni	W.		25	50.36	+ .01	— .02	— .03	— .21	.00		25	50.11		25	35.67	14.44
	κ Aquilæ	W.		30	17.45	+ .01	— .01	— .02	— .47	.00		30	16.96		30	02.47	14.49
	γ Aquilæ	W.		40	27.38	+ .02	— .02	— .02	— .35	.00		40	27.01		40	12.53	14.48
	Altair	W.		44	49.22	+ .02	— .01	— .02	— .36	.00		44	48.84		44	34.36	14.48
	ε Draconis	W.		48	53.39	+ .03	— .04	— .08	+ .66	.00		48	53.96		48	39.33	14.63*
	ε Draconis	E.	19	48	52.95	+ .03	— .04	+ .02	+ .66	.00	19	48	53.62	19	48	39.33	14.29*
July 23	α Serpentis	W.	15	38	11.22	— .04	— .02	— .04	+ .27	— .04	15	38	11.35	15	37	59.21	12.14
	ζ Ursæ Minoris	W.		48	57.55	— .03	— .07	— .22	—1.05	— .21		48	55.97		48	43.79	12.18*
	δ Scorpii	E.		52	59.45	— .03	— .02	+ .01	+0.37	+ .05		52	59.83		52	47.66	12.17
	β^1 Scorpii	E.	15	58	13.29	— .02	— .02	+ .01	+ .36	+ .04	15	58	13.66	15	58	01.40	12.26
	Groom. 2320	E.	16	06	13.74	— .02	— .04	+ .02	— .36	+ .11	16	06	13.45	16	06	01.06	12.39*
	τ Herculis	E.		16	07.47	.00	— .02	.00	.00	+ .06		16	07.51		15	55.36	12.15
	η Draconis	E.		22	29.91	.00	— .03	.00	— .20	+ .09		22	29.80		22	17.79	12.01
Set I	A Draconis	E.		28	29.50	.00	— .04	.00	— .39	+ .12		28	29.19		28	17.04	12.15*
	A Draconis	W.		28	29.65	+ .01	— .04	— .07	— .22	— .12		28	29.21		28	17.04	12.17*
	η Herculis	W.		38	44.50	+ .02	— .02	— .04	+ .04	— .05		38	44.45		38	32.24	12.21
	9 Camelop., L. C	W.		41	31.19	+ .02	+ .04	+ .03	+ .48	+ .10		41	31.86		41	19.60	12.26*
	κ Ophiuchi	W.		51	50.42	+ .03	— .02	— .02	+ .13	— .04		51	50.50		51	38.29	12.21
	ε Ursæ Minoris	W.		59	29.49	+ .03	— .11	— .17	— .91	— .31		59	28.02		59	15.78	12.24*
	ε Ursæ Minoris	E.	16	59	28.36	+ .01	— .11	+ .27	— .91	+ .31	16	59	27.96	16	59	15.78	12.18*
July 23	ε Aquilæ	E.	18	54	02.90	— .04	— .02	+ .01	— .10	+ .05	18	54	02.80	18	53	50.83	11.97
	ζ Aquilæ	E.	18	59	45.71	— .03	— .02	+ .01	— .10	+ .05	18	59	45.62	18	59	33.64	11.98
	d Sagittarii	E.	19	10	23.26	— .02	— .01	.00	— .18	+ .05	19	10	23.10	19	10	10.99	12.11
	δ Draconis	E.		12	46.23	— .02	— .04	+ .03	+ .17	+ .12		12	46.49		12	34.50	11.99*
	τ Draconis	E.		18	15.85	— .01	— .05	+ .04	+ .29	+ .15		18	16.27		18	04.21	12.06*
	τ Draconis	W.		18	16.33	— .01	— .05	— .06	+ .16	— .15		18	16.22		18	04.21	12.01*
Set II	κ Aquilæ	W.		30	14.74	.00	— .01	— .01	— .09	— .05		30	14.58		30	02.49	12.09
	γ Aquilæ	W.		40	24.65	+ .01	— .01	— .01	— .06	— .05		40	24.53		40	12.54	11.99
	Altair	W.		44	46.50	+ .01	— .01	— .01	— .07	— .04		44	46.38		44	34.38	12.00
	ε Draconis	W.		48	51.44	+ .01	— .01	— .03	+ .12	— .13		48	51.37		48	39.31	12.06*
	ε Draconis	E.		48	50.84	+ .01	— .04	+ .07	+ .16	+ .13		48	51.17		48	39.31	12.86*
	τ Aquilæ	E.	19	58	07.42	+0.02	—0.01	+0.02	—0.09	+0.05	19	58	07.41	19	57	55.31	—12.10

Computation of observations for clock and instrumental corrections, &c.—Continued.

Dates.	Stars.	L. p.	Observed time of transit.			Corrections. Rate.	Aberration.	Level.	Azimuth.	Collimation.	Clock-time of meridian transit.			Right ascension.			Clock correct.
1872.			*h.*	*m.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*s.*
July 23 Set II.	3 Ursæ Majoris, L. C	E.	20	00	13. 24	+0 03	+0. 04	−0. 05	−0. 36	−0. 12	20	00	12. 78	20	00	00. 78	−12. 00*
	κ Cephei	E.	20	13	25. 89	+ . 04	− . 07	+ . 22	+ . 33	+ . 21	20	13	26. 62	20	13	14. 53	12. 09*
Set III.	9 Draconis, L. C	E.	22	24	19. 81	− . 01	+ . 06	+ . 02	−1. 45	− . 19	22	24	18. 24	22	24	06. 48	11. 76*
	η Aquarii	E.		29	00. 61	− . 01	− . 01	. 00	−0. 30	+ . 04		29	00. 33		28	48. 57	11. 76
	226 Cephei	E.		30	15. 58	− . 01	− . 06	− . 03	+ . 79	+ . 18		30	16. 45		30	04. 81	11. 64*
	ζ Pegasi	E.		35	18. 53	. 00	− . 01	− . 01	− . 25	+ . 04		35	18. 30		35	06. 52	11. 78
	ι Cephei	E.		45	21. 68	. 00	− . 03	− . 02	+ . 31	+ . 11		45	22. 05		45	10. 21	11. 84*
	ι Cephei	W.		45	21. 97	. 00	− . 03	− . 01	+ . 32	− . 11		45	22. 14		45	10. 21	11. 93*
	o Andromedæ	W.		56	15. 87	+ . 01	− . 02	− . 01	− . 05	− . 06		56	15. 74		56	03. 95	11. 79
	α Pegasi	W.	22	58	36. 94	+ . 02	− . 02	− . 01	− . 23	− . 04	22	58	36. 66	22	58	24. 88	11. 78
July 28	η Draconis	W.	16	22	23. 43	− . 05	− . 03	− . 13	− . 27	− . 02	16	22	22. 93	16	22	17. 61	5. 32
	A Draconis	W.		28	22. 92	− . 05	− . 04	− . 17	− . 52	− . 03		28	22. 11		28	16. 79	5. 32*
	η Herculis	W.		38	37. 47	− . 04	− . 02	− . 08	+ . 08	− . 01		38	37. 40		38	32. 16	5. 24
	κ Ophiuchi	W.		51	43. 31	− . 03	− . 01	− . 05	+ . 30	− . 01		51	43. 51		51	38. 25	5. 26
	ε Ursæ Minoris	W.		59	23. 10	− . 02	− . 11	− . 40	−2. 13	− . 07		59	20. 37		59	15. 07	5. 30*
	ε Ursæ Minoris	E.	16	59	22. 77	− . 02	− . 11	− . 03	−2. 22	+ . 07	16	59	20. 46	16	59	15. 07	5. 39*
	α¹ Herculis	E.	17	08	55. 43	− . 01	− . 01	− . 01	+0. 28	+ . 01	17	08	55. 69	17	08	50. 40	5. 29
	π Herculis	E.		10	42. 26	− . 01	− . 02	− . 01	+ . 11	+ . 01		10	42. 34		10	37. 19	5. 15
	44 Ophiuchi	E.		18	40. 22	. 00	− . 02	. 00	+ . 53	+ . 01		18	40. 74		18	35. 29	5. 45
	Groom. 966, L. C.	E.		22	39. 46	. 00	+ . 06	+ . 02	+1. 69	− . 03		22	41. 22		22	35. 86	5. 36*
	β Draconis	E.		27	39. 90	. 00	− . 02	− . 02	−0. 08	+ . 01		27	39. 79		27	34. 53	5. 26
	ω Draconis	E.		37	50. 75	+ . 01	− . 04	− . 04	− . 54	+ . 03		37	50. 17		37	44. 93	5. 24*
	ψ¹ Draconis	E.		44	22. 33	+ . 02	− . 05	− . 04	− . 73	+ . 03		44	21. 56		44	16. 23	5. 33*
	ψ¹ Draconis	W.		44	22. 47	+ . 02	− . 05	− . 16	− . 55	− . 03		44	21. 70		44	16. 23	5. 47*
	γ Draconis	W.	17	53	45. 70	+ . 03	− . 02	− . 09	− . 05	− . 01	17	53	45. 56	17	53	40. 11	5. 45
	o Herculis	W.	18	02	40. 10	+ . 04	− . 02	− . 06	+ . 14	− . 01	18	02	40. 19	18	02	34. 89	5. 30
	δ Ursæ Minoris	W.		14	01. 78	+ . 05	− . 24	− . 68	−4. 24	− . 15		13	56. 52		13	51. 22	5. 30*
	1 Aquilæ	W.	18	28	21. 56	+ . 06	− . 01	− . 03	+0. 32	− . 01	18	28	21. 89	18	28	16. 59	5. 30
July 29	ζ Ophiuchi	W.	16	30	12. 28	− . 04	− . 02	− . 05	− . 08	+ . 01	16	30	12. 10	16	30	08. 36	3. 74
	η Herculis	W.		38	36. 03	− . 03	− . 02	− . 13	− . 02	+ . 01		38	35. 84		38	32. 14	3. 70
	9 Camelop., L. C	W.		41	24. 00	− . 03	+ . 04	+ . 10	− . 20	− . 02		41	23. 89		41	19. 97	3. 92*
	κ Ophiuchi	W.		51	42. 18	− . 02	− . 02	− . 09	− . 05	+ . 01		51	42. 01		51	38. 24	3. 77
	ε Ursæ Minoris	W.		59	19. 13	− . 01	− . 11	− . 66	+ . 38	+ . 04		59	18. 77		59	14. 93	3. 84*
	ε Ursæ Minoris	E.	16	59	18. 76	− . 02	− . 11	− . 33	+ . 54	− . 04	16	59	18. 80	16	59	14. 93	3. 87*
	α¹ Herculis	E.	17	08	54. 30	− . 01	− . 01	− . 05	− . 07	− . 01	17	08	54. 15	17	08	50. 39	3. 76
	44 Ophiuchi	E.		18	39. 40	. 00	− . 02	− . 02	− . 13	− . 01		18	39. 22		18	35. 28	3. 94
	Groom. 966, L. C.	E.		22	39. 94	+ . 01	+ . 05	+ . 12	− . 41	+ . 02		22	39. 73		22	35. 95	3. 78*
	β Draconis	E.		27	38. 35	+ . 01	− . 02	− . 10	+ . 02	− . 01		27	38. 25		27	34. 51	3. 74
	ω Draconis	E.		37	48. 66	+ . 02	− . 04	− . 17	+ . 13	− . 02		37	48. 58		37	44. 89	3. 69*
	ψ¹ Draconis	E.		44	19. 98	+ . 02	− . 05	− . 19	+ . 18	− . 02		44	19. 92		44	16. 18	3. 74*
	ψ¹ Draconis	W.		44	20. 37	+ . 03	− . 05	− . 32	− . 06	+ . 02		44	19. 99		44	16. 18	3. 81*
	γ Draconis	W.	17	53	44. 13	+ . 03	− . 02	− . 17	− . 01	+ . 01	17	53	43. 97	17	53	40. 09	3. 88
	o Herculis	W.	18	02	38. 82	+ . 04	− . 02	− . 11	+ . 02	+ . 01	18	02	38. 76	18	02	34. 88	3. 88
July 30	γ Draconis	E.	17	53	42. 73	− . 07	− . 02	− . 10	− . 03	+ . 02	17	53	42. 53	17	53	40. 07	2. 46
	δ Ursæ Minoris	E.	18	13	56. 51	− . 05	− . 24	− . 86	−2. 60	+ . 24	18	13	53. 00	18	13	50. 63	2. 37*
	Vega	E.		32	40. 69	− . 03	− . 02	− . 09	+0. 04	+ . 02		32	40. 61		32	38. 34	2. 27
	β Lyræ	W.	18	45	25. 66	− . 02	− . 02	− . 05	+ . 05	− . 02	18	45	25. 60	18	45	23. 27	2. 33
	δ Draconis	W.	19	12	36. 94	+ . 01	− . 04	− . 11	− . 15	− . 04	19	12	36. 61	19	12	34. 37	2. 24*
	γ Aquilæ	W.		40	14. 90	+ . 03	− . 01	− . 03	+ . 10	− . 01		40	14. 98		40	12. 57	2. 41
	Altair	W.		44	36. 68	+ . 04	− . 02	− . 03	+ . 10	− . 01		44	36. 76		44	34. 41	2. 35
	ε Draconis	W.		48	42. 01	+ . 01	− . 04	− . 09	− . 19	− . 04		48	41. 69		48	39. 22	2. 47*
	ε Draconis	E.	19	48	41. 89	+ . 04	− . 04	+ . 10	− . 19	+ . 04	19	48	41. 84	19	48	39. 22	2. 62*
July 31 Set I.	ζ Ophiuchi	E.	16	30	08. 91	− . 05	− . 01	. 00	+ . 30	. 00	16	30	09. 15	16	30	08. 34	0. 81
	η Herculis	E.		38	32. 92	− . 04	− . 02	. 00	+ . 06	. 00		38	32. 92		38	32. 11	0. 81
	9 Camelop., L. C	E.		41	20. 30	− . 04	+ . 04	. 00	+ . 81	. 00		41	21. 11		41	20. 09	1. 02*
	κ Ophiuchi	E.		51	38. 95	− . 03	− . 02	. 00	+ . 22	. 00		51	39. 12		51	38. 22	0. 90
	ε Ursæ Minoris	E.		59	17. 27	− . 02	− . 11	− . 02	−1. 54	− . 01		59	15. 57		59	14. 63	0. 94*
	ε Ursæ Minoris	W.	16	59	17. 62	−0. 02	−0. 11	−0. 36	−1. 52	+0. 01	16	59	15. 62	16	59	14. 63	− 0. 99*

Computation of observations for clock and instrumental corrections, &c.—Continued.

Dates.	Stars.	L. p.	Observed time of transit. h.	m.	s.	Corrections. Rate.	Aberration.	Level.	Azimuth.	Collimation.	Clock-time of meridian transit. h.	m.	s.	Right ascension. h.	m.	s.	Clock correct.
1872.			h.	m.	s.	s.	s.	s.	s.	s.	h.	m.	s.	h.	m.	s.	s.
July 31	a^1 Herculis	W.	17	08	51.12	−0.01	−0.01	−0.05	+0.19	0.00	17	08	51.24	17	08	50.37	−0.87
	44 Ophiuchi	W.		18	35.98	−.01	−.02	−.02	+.37	.00		18	36.30		18	35.27	1.03
	β Draconis	W.		27	35.48	.00	−.02	−.10	−.06	.00		27	35.30		27	34.47	0.83
	ω Draconis	W.		37	46.14	+.01	−.04	−.17	−.37	.00		37	45.57		37	44.80	0.77*
Set I	ψ^1 Draconis	W.		44	17.68	+.02	−.05	−.19	−.50	.00		44	16.96		44	16.08	0.88*
	ψ^1 Draconis	E.		44	17.43	+.02	−.05	.00	−.27	.00		44	17.13		44	16.08	1.05*
	γ Draconis	E.	17	53	41.00	+.03	−.02	.00	−.01	.00	17	53	40.98	17	53	40.05	0.93
	o Herculis	E.	18	02	35.66	+.04	−.02	.00	+.07	.00	18	02	35.75	18	02	34.86	0.89
	δ Ursæ Minoris	E.		13	53.39	+.05	−.24	+.07	−2.05	−.02		13	51.20		13	50.31	0.89*
	1 Aquilæ	E.	18	28	17.36	+.06	−.01	.00	+0.16	.00	18	28	17.57	18	28	16.59	0.98
July 31.	ι Cephei	W.	22	45	11.30	−.04	−.03	−.15	+.17	−.06	22	45	11.19	22	45	10.47	0.72*
	Fomalhaut	W.		50	37.68	−.03	−.02	−.02	−.25	−.03		50	37.33		50	36.72	0.61
	α Pegasi	W.	22	58	25.84	−.03	−.01	−.05	−.12	−.03	22	58	25.60	22	58	25.05	0.55
	o Cephei	W.	23	13	26.25	−.01	−.04	−.16	+.20	−.06	23	13	26.18	23	13	25.44	0.74*
	λ Draconis, L. C	W.		23	46.76	.00	+.04	+.10	−.59	+.07		23	46.38		23	45.64	0.74*
Set II	λ Draconis, L. C	E.		23	46.63	.00	+.04	+.02	−.36	−.07		23	46.26		23	45.64	0.62*
	λ Andromedæ	E.		31	20.91	.00	−.02	−.02	.00	+.04		31	20.91		31	20.32	0.59
	γ Cephei	E.		34	10.86	+.01	−.06	−.07	+.30	+.11		34	11.15		34	10.53	0.62*
	φ Pegasi	E.		46	01.20	+.02	−.01	−.01	−.07	+.03		46	01.16		46	00.41	0.75
	ρ Cassiopeæ	E.		48	02.54	+.02	−.03	−.01	+.04	+.05		48	02.61		48	01.90	0.71
	ω Piscium	E.	23	52	46.80	+.03	−.01	.00	−.09	+.02	23	52	46.75	23	52	46.06	0.69
	α Andromedæ	E.	0	01	48.69	+.04	−.02	+.01	−.05	+.03	0	01	48.70	0	01	48.15	−0.55
Aug. 1.	ε Ursæ Minoris	E.	16	59	16.08	−.07	−.11	−.16	−1.65	+.01	16	59	14.10	16	59	14.48	+0.38*
	a^1 Herculis	E.	17	08	49.69	−.06	−.01	−.02	+0.21	.00	17	08	49.81	17	08	50.36	0.55
	44 Ophiuchi	E.		18	34.59	−.06	−.02	.00	+.40	.00		18	34.91		18	35.26	0.35
	β Draconis	E.		27	34.14	−.05	−.02	−.03	−.06	.00		27	33.98		27	34.44	0.46
	μ^1 Herculis	E.		41	28.26	−.03	−.02	−.02	+.14	.00		41	28.33		41	28.76	0.43
	ψ^1 Draconis	E.		44	16.08	−.03	−.05	−.06	−.54	.00		44	15.40		44	16.03	0.63*
	ψ^1 Draconis	W.		44	16.30	−.03	−.05	−.19	−.22	.00		44	15.81		44	16.03	0.22*
	γ Draconis	W.	17	53	39.84	−.02	−.02	−.11	−.02	.00	17	53	39.67	17	53	40.03	0.36
	o Herculis	W.	18	02	34.36	−.01	−.02	−.07	+.06	.00	18	02	34.32	18	02	34.85	0.53
Set I	δ Ursæ Minoris	W.		13	52.33	.00	−.24	−.86	−1.68	−.02		13	49.53		13	49.99	0.46*
	ψ Draconis	W.		23	25.13	+.01	−.05	−.18	−0.23	.00		23	24.68		23	25.01	0.33*
	1 Aquilæ	W.		28	16.10	+.01	−.02	−.03	+.13	.00		28	16.19		28	16.58	0.39
	Vega	W.		32	37.78	+.02	−.02	−.07	+.03	.00		32	37.74		32	38.32	0.58
	β Lyræ	W.		45	22.83	+.03	−.02	−.06	+.04	.00		45	22.82		45	23.26	0.44
	50 Draconis	W.		50	33.24	+.04	−.06	−.19	−.29	.00		50	32.74		50	33.48	0.74*
	50 Draconis	E.		50	33.28	+.04	−.06	+.03	−.16	.00		50	33.13		50	33.48	0.35*
	ε Aquilæ	E.		53	50.34	+.04	−.01	+.01	+.05	.00		53	50.43		53	50.82	0.39
	ζ Aquilæ	E.	18	59	33.12	+.05	−.02	+.01	+.05	.00	18	59	33.21	18	59	33.64	0.43
	δ Draconis	E.	19	12	33.74	+.06	−.04	+.02	−.08	.00	19	12	33.70	19	12	34.32	0.62*
	δ Draconis	W.	19	12	33.87	+.06	−.04	−.13	−.08	.00	19	12	33.68	19	12	34.32	0.64*
Aug. 1.	γ Piscium	W.	23	10	33.34	−.02	−.01	−.03	−.29	.00	23	10	32.99	23	10	33.69	0.70
	o Cephei	W.		13	24.63	−.01	−.04	−.11	+.39	.00		13	24.86		13	25.48	0.62*
	υ Pegasi	W.		19	00.90	−.01	−.01	−.05	−.19	.00		19	00.64		19	01.43	0.79
	θ Piscium	W.		21	29.97	−.01	−.01	−.04	−.28	.00		21	29.63		21	30.41	0.78
Set II	λ Draconis, L. C	W.		23	45.90	.00	+.04	+.07	−1.10	.00		23	44.91		23	45.61	0.70*
	γ Cephei	W.		34	09.16	+.01	−.06	−.21	+0.93	.00		34	09.83		34	10.60	0.77*
	γ Cephei	E.	23	34	09.11	+.01	−.06	−.02	+.86	.00	23	34	09.90	23	34	10.60	0.70*
	α Andromedæ	E.	0	01	47.66	+.03	−.02	.00	−.14	.00	0	01	47.53	0	01	48.18	0.65
Aug. 2	η Draconis	W.	16	22	15.75	−.06	−.03	−.11	+.14	−.01	16	22	15.68	16	22	17.42	1.74
	A Draconis	W.		28	14.96	−.05	−.04	−.14	+.28	−.01		28	15.00		28	16.53	1.53*
	η Herculis	W.		38	30.40	−.04	−.02	−.07	−.04	.00		38	30.23		38	32.07	1.84
	9 Camelop., L. C	W.		41	19.14	−.04	+.03	+.05	−.59	+.01		41	18.60		41	20.22	1.62*
	κ Ophiuchi	W.		51	36.64	−.03	−.02	−.04	−.16	.00		51	36.39		51	38.20	1.81
	ε Ursæ Minoris	W.		59	11.93	−.02	−.11	−.28	+1.12	−.03		59	12.61		59	14.33	1.72*
	ε Ursæ Minoris	E.	16	59	11.99	−.02	−.11	−.08	+0.95	+.03	16	59	12.76	16	59	14.33	1.57*
	a^1 Herculis	E.	17	08	48.75	−.01	−.02	−.01	−.12	.00	17	08	48.59	17	08	50.35	1.76
	44 Ophiuchi	E.	17	18	33.94	0.00	−0.02	0.00	−0.23	0.00	17	18	33.69	17	18	35.25	+1.56

Computation of observations for clock and instrumental corrections, &c.—**Continued.**

Dates.	Stars.	L. p	Observed time of transit.			Corrections. Rate.	Aberration.	Level	Azimuth	Collimation	Clock-time of meridian transit.			Right ascension.			Clock correct.
1872.			h.	m.	s.	s.	s.	s.	s.	s.	h.	m.	s.	h.	m.	s.	s.
Aug. 2	β Draconis..........	E.	17	27	32.61	—0.00	—0.02	+0.01	+0.03	+0.01	17	27	32.64	17	27	34.42	+ 1.78
	α Ophiuchi	E.		28	59.81	+ .01	— .01	+ .01	— .13	.00		28	59.69		29	01.35	1.66
	ω Draconis..........	E.		37	42.57	+ .02	— .04	+ .01	+ .23	+ .01		37	42.80		37	44.71	1.91*
	ψ^1 Draconis..........	E.		44	13.80	+ .02	— .05	+ .02	+ .31	+ .01		44	14.11		44	15.97	1.86*
	ψ^1 Draconis..........	W.		44	13.92	+ .02	— .05	— .16	+ .63	— .01		44	14.35		44	15.97	1.62*
	γ Draconis	W.	17	53	38.43	+ .03	— .02	— .09	+ .06	— .01	17	53	38.40	17	53	40.01	1.61
	o Herculis..........	W.	18	02	33.29	+ .04	— .02	— .06	— .16	.00	18	02	33.09	18	02	34.84	1.75
	δ Ursæ Minoris......	W.		13	44.04	+ .05	— .24	— .71	+4.88	— .07		13	47.95		13	49.67	1.72*
	1 Aquilæ	W.	18	28	15.23	+ .07	— .02	— .02	—0.37	— .01	18	28	14.88	18	28	16.58	1.70
Aug. 3	ε Ursæ Minoris	W.	16	59	10.81	— .03	— .11	— .33	+ .85	+ .07	16	59	11.26	16	59	14.18	2.92*
	a^1 Herculis	W.	17	08	47.47	— .02	— .01	— .05	— .11	+ .01	17	08	47.29	17	08	50.34	3.05
	44 Ophiuchi	W.		18	32.55	— .01	— .02	— .02	— .20	+ .01		18	32.31		18	35.24	2.93
	β Draconis..........	W.		27	31.35	.00	— .02	— .09	+ .03	+ .01		27	31.28		27	34.40	3.12
	α Ophiuchi	W.		28	58.47	.00	— .01	— .05	— .11	+ .01		28	58.31		29	01.34	3.03
	ω Draconis..........	W.		37	41.42	+ .01	— .04	— .14	+ .20	+ .03		37	41.48		37	44.66	3.18*
	μ Herculis..........	W.		41	25.83	+ .01	— .02	— .06	— .07	+ .01		41	25.70		41	28.74	3.04
	ψ^1 Draconis..........	W.		44	12.54	+ .01	— .05	— .16	+ .28	+ .03		44	12.65		44	15.91	3.26*
	ψ^1 Draconis	E.		44	12.48	+ .02	— .05	+ .02	+ .41	— .03		44	12.85		44	15.91	3.06*
	γ Draconis..........	E.	17	53	36.98	+ .02	— .02	+ .01	+ .04	— .02	17	53	37.01	17	53	39.99	2.98
Aug. 6	ε Ursæ Minoris......	E.	16	59	07.63	— .06	— .11	— .09	—1.34	+ .30	16	59	06.33	16	59	13.71	7.38*
	a^1 Herculis..........	E.	17	08	42.67	— .05	— .01	— .02	+0.17	+ .04	17	08	42.80	17	08	50.30	7.50
	44 Ophiuchi	E.		18	27.56	— .04	— .02	— .01	+ .32	+ .04		18	27.85		18	35.21	7.36
	β Draconis..........	E.		27	26.81	— .04	— .02	— .05	— .05	+ .07		27	26.72		27	34.32	7.60
	α Ophiuchi	E.		28	53.65	— .03	— .01	— .03	+ .18	+ .04		28	53.80		29	01.31	7.51
	ω Draconis	E.		37	37.18	— .02	— .04	— .08	— .32	+ .11		37	36.83		37	44.52	7.69*
	μ Herculis..........	E.		41	21.09	— .02	— .02	— .03	+ .11	+ .05		41	21.18		41	28.71	7.53
	ψ^1 Draconis..........	E.		44	08.51	— .02	— .05	— .09	— .43	+ .13		44	08.05		44	15.74	7.69*
	ψ^1 Draconis.	W.		44	09.05	— .02	— .05	— .23	— .17	— .13		44	08.45		44	15.74	7.29*
Set I...	γ Draconis..........	W.	17	53	32.75	— .01	— .02	— .12	— .02	— .06	17	53	32.52	17	53	39.93	7.41
	o Herculis..........	W.	18	02	27.41	.00	— .01	— .08	+ .04	— .05	18	02	27.31	18	02	34.80	7.49
	δ Ursæ Minoris	W.		13	44.08	+ .01	— .24	— .88	—1.31	— .68		13	40.98		13	48.48	7.50*
	1 Aquilæ	W.		28	09.03	+ .02	— .01	— .05	+0.10	— .04		28	09.05		28	16.56	7.51
	Vega	W.		32	30.83	+ .03	— .02	— .11	+ .02	— .05		32	30.70		32	38.27	7.57
	β Lyræ	W.		45	15.83	+ .04	— .02	— .11	+ .03	— .05		45	15.72		45	23.23	7.51
	50 Draconis..........	W.		50	26.10	+ .04	— .06	— .34	— .23	— .15		50	25.36		50	33.22	7.86*
	50 Draconis	E.		50	25.80	+ .04	— .06	— .12	— .07	+ .16		50	25.75		50	33.22	7.47*
	ζ Aquilæ	E.	18	59	26.06	+ .05	— .01	— .03	+ .02	+ .04	18	59	26.13	18	59	33.62	7.49
	δ Draconis..........	E.	19	12	26.56	+ .07	— .04	— .10	— .03	+ .10	19	12	26.56	19	12	34.19	7.63*
Aug. 6	γ Piscium	E	23	10	26.35	— .02	— .01	— .02	— .24	+ .02	23	10	26.08	23	10	33.79	7.71
	o Cephei..........	E.		13	17.76	— .02	— .04	— .07	+ .31	+ .04		13	17.98		13	25.65	7.67*
	θ Piscium	E.		21	22.93	— .02	— .01	— .02	— .22	+ .02		21	22.68		21	30.51	7.83
	λ Draconis, L. C	E.		23	38.70	— .01	+ .04	+ .04	— .88	— .05		23	37.84		23	45.50	7.66*
Set II..	γ Cephei..........	E.		34	02.55	.00	— .06	— .12	+ .75	+ .07		34	03.19		34	10.89	7.70*
	γ Cephei..........	W.		34	02.80	.00	— .06	— .30	+ .76	— .07		34	03.13		34	10.89	7.76*
	φ Pegasi	W.		45	52.99	+ .01	— .02	— .07	— .17	— .02		45	52.72		46	00.55	7.83
	ρ Cassiopeæ..........	W.		47	54.59	+ .01	— .03	— .13	+ .11	— .03		47	54.52		48	02.10	7.58
	ω Piscium	W.	23	52	38.76	+ .02	— .02	— .05	— .23	— .02	23	52	38.46	23	52	46.20	7.74
	α Andromedæ	W.	0	01	40.80	+ .03	— .02	— .07	— .12	— .02	0	01	40.60	0	01	48.30	7.70
Aug. 9	η Draconis..........	E.	16	22	05.46	— .07	— .03	+ .10	+ .02	+ .04	16	22	05.52	16	22	17.14	11.62
	ζ Ophiuchi	E.		29	56.58	— .06	— .01	+ .01	— .03	+ .02		29	56.51		30	08.24	11.73
	η Herculis..........	E.		38	20.21	— .05	— .02	+ .03	— .01	+ .02		38	20.18		38	31.93	11.75
	9 Camelop., L. C	E.		41	09.16	— .05	+ .04	— .03	— .07	— .04		41	09.01		41	20.68	11.67*
	κ Ophiuchi	E.		51	26.46	— .04	— .01	+ .03	— .02	+ .02		51	26.44		51	38.12	11.68
	ε Ursæ Minoris......	E.		59	01.21	— .03	— .11	+ .23	+ .13	+ .13		59	01.56		59	13.24	11.68*
	ε Ursæ Minoris......	W.	16	59	02.05	— .03	— .11	— .19	+ .09	— .13	16	59	01.68	16	59	13.24	11.56*
	44 Ophiuchi	W.	17	18	23.81	— .02	— .02	— .01	— .02	— .02	17	18	23.72	17	18	35.18	11.46
	β Draconis..........	W.		27	22.71	— .01	— .02	— .08	.00	— .03		27	22.57		27	34.24	11.67
	α Ophiuchi	W.		28	49.73	— .01	— .01	— .05	— .01	— .02		28	49.63		29	01.28	11.65
	ω Draconis..........	W.	17	37	32.93	0.00	—0.04	—0.16	+0.02	—0.04	17	37	32.71	17	37	44.37	+11.66*

Computation of observations for clock and instrumental corrections, &c.—Continued.

Dates.	Stars.	L. p.	Observed time of transit.	Corrections. Rate.	Aberration.	Level.	Azimuth.	Collimation.	Clock-time of meridian transit.	Right ascension.	Clock correct.
1872.			h. m. s.	s.	s.	s.	s.	s.	h. m. s.	h. m. s.	s.
Aug. 9	ψ^1 Draconis	W.	17 44 04.11	+0.01	—0.04	—0.18	+0.03	—0.06	17 44 03.87	17 44 15.56	+11.69*
	ψ^1 Draconis	E.	44 03.56	+ .01	— .05	+ .07	+ .42	+ .06	44 04.07	44 15.56	11.49*
	γ Draconis	E.	17 53 28.24	+ .02	— .02	+ .04	+ .04	+ .03	17 53 28.35	17 53 39.86	11.51
	o Herculis	E.	18 02 23.22	+ .02	— .02	+ .04	— .10	+ .02	18 02 23.18	18 02 34.77	11.59
	δ Ursæ Minoris	E.	13 32.04	+ .04	— .24	+ .66	+3.20	+ .29	13 35.99	13 47.62	11.63*
	1 Aquilæ	E.	28 05.23	+ .05	— .02	+ .03	—0.25	+ .02	28 05.06	28 16.54	11.48
	Vega	W.	32 26.67	+ .05	— .02	— .05	— .08	— .02	32 26.55	32 38.23	11.68
	β Lyræ	W.	45 11.65	+ .06	— .02	— .04	— .12	— .02	45 11.51	45 23.20	11.69
	50 Draconis	W.	50 20.71	+ .07	— .06	— .11	+ .85	— .07	50 21.39	50 33.04	11.65*
	ζ Aquilæ	W.	18 59 22.19	+ .08	— .02	— .02	— .25	— .02	18 59 21.96	18 59 33.60	11.64
Aug. 10	κ Ophiuchi	W.	16 51 25.23	— .06	— .01	— .03	+ .06	— .03	16 51 25.16	16 51 38.11	12.95
	ϵ Ursæ Minoris	W.	16 59 01.31	— .05	— .11	— .20	— .43	— .21	16 59 00.31	16 59 13.07	12.76*
	α^1 Herculis	W.	17 08 37.43	— .04	— .02	— .03	+ .06	— .03	17 08 37.37	17 08 50.26	12.89
	44 Ophiuchi	W.	18 22.45	— .03	— .01	— .02	+ .10	— .03	18 22.46	18 35.17	12.71
	β Draconis	W.	27 21.45	— .02	— .02	— .09	— .02	— .05	27 21.25	27 34.22	12.97
	α Ophiuchi	W.	28 48.46	— .02	— .01	— .05	+ .06	— .03	28 48.41	29 01.27	12.86
	ω Draconis	W.	37 31.73	— .02	— .04	— .15	— .10	— .08	37 31.34	37 44.32	12.98*
	μ Herculis	W.	41 15.81	— .01	— .02	— .06	+ .04	— .03	41 15.73	41 28.65	12.92
	ψ^1 Draconis	W.	44 02.87	— .01	— .05	— .17	— .14	— .09	44 02.41	44 15.50	13.09*
	ψ^1 Draconis	E.	44 02.61	— .01	— .05	+ .03	+ .20	+ .09	44 02.87	44 15.50	12.63*
	γ Draconis	E.	17 53 26.95	.00	— .02	+ .02	+ .02	+ .04	17 53 27.01	17 53 39.83	12.82
	o Herculis	E.	18 02 21.88	+ .01	— .02	+ .01	— .05	+ .03	18 02 21.86	18 02 34.75	12.89
	δ Ursæ Minoris	E.	13 32.42	+ .02	— .24	+ .19	+1.54	+ .47	13 34.40	13 47.31	12.91*
	1 Aquilæ	E.	28 03.75	+ .03	— .01	.00	—0.12	+ .03	28 03.68	28 16.54	12.86
	Vega	E.	32 25.18	+ .04	— .02	.00	— .03	+ .04	32 25.21	32 38.21	13.00
	β Lyræ	E.	45 10.20	+ .05	— .02	— .01	— .04	+ .03	45 10.21	45 23.19	12.98
	50 Draconis	E.	50 19.72	+ .05	— .06	— .02	+ .27	+ .11	50 20.07	50 32.98	12.91*
	50 Draconis	W.	50 20.00	+ .05	— .05	— .10	+ .32	— .11	50 20.11	50 32.98	12.87*
	ζ Aquilæ	W.	18 59 20.86	+0.06	—0.01	—0.02	—0.10	—0.03	18 59 20.76	18 59 33.60	+12.84

St. Pierre clock-corrections, deduced from stars of less than 65° *N. declination.*

Date.	T_0	Number of time-stars.	ΔT_0	Date.	T_0	Number of time-stars.	ΔT_0
1872.	h. m.		s.	1872.	h. m.		s.
July 9	15 25	6	—30.609	July 23	22 40	4	—11.779
9	18 36	10	30.465	28	17 22	10	5.302
10	15 09	3	29.132	29	17 16	8	3.802
12	15 13	4	26.307	30	19 05	5	2.365
14	15 41	9	23.597	31	17 24	9	0.893
14	18 27	9	23.553	31	23 26	7	— 0.635
17	15 52	9	19.727	August 1	18 13	11	+ 0.448
17	18 43	8	19.733	1	23 27	4	0.731
18	15 59	9	18.472	2	17 21	10	1.719
20	20 54	5	15.700	3	17 30	6	3.025
21	16 02	9	14.571	6	18 03	11	7.498
21	19 19	8	14.476	6	23 35	6	7.732
23	16 22	7	12.162	9	17 37	13	11.628
23	19 33	7	—12.033	10	17 55	12	+12.892

NOTE.—The slight differences between the mean clock-corrections given in this table and those derived from the computations as here published, are due to the fact that in the original computation, from which this table is formed, the clock-correction resulting from each star is given to the thousandth place.

Table of adopted clock-corrections, Cambridge and St. Pierre, at epochs of exchanging longitude signals.

Date.	Cambridge clock.		St. Pierre chronometer.	
	Sidereal time.	Corrections.	Sidereal time.	Corrections.
1872.	h. m.	s.	h. m.	s.
July 21	19 47	− 4. 842	20 47	−14. 433
21...........	20 02	4. 840	21 02	14. 426
23...........	20 08	4. 357	21 08	11. 904
23...........	20 23	4. 355	21 23	11. 884
28...........	20 31	3. 639	21 31	5. 041
28...........	21 12	3. 640	22 12	4. 998
28...........	21 38	3. 640	22 38	4. 971
29...........	21 50	4. 065	22 50	3. 477
29...........	22 03	4. 072	23 03	3. 464
29...........	22 08	4. 075	23 08	− 3. 459
August 1...........	21 06	8. 399	22 06	+ 0. 658
1...........	21 16	8. 412	22 15	0. 666
6...........	21 12	21. 202	22 11	7. 673
6...........	21 21	21. 219	22 21	7. 680
9...........	21 57	29. 611	22 56	11. 905
9...........	22 09	− 29. 632	23 08	+11. 915

Table of such clock corrections and rates at St. Pierre as relate to the longitude determinations with Brest.

Date.	T_0	ΔT_0	Hourly difference.	Adopted hourly rate at epoch of exchange.	Clock-correction at $17^h 0^m$.
1872.	h. m.	s.	s.	s.	s.
July 9............	15 25	−30. 609	+0. 0452	+0. 0452	−30. 537
9............	18 36	30. 465			
10............	15 09	29. 132	+0. 0588		
12	15 13	26. 307	+0. 0559	+0. 0574	26. 205
14............	15 41	23. 597	+0. 0159	+0. 0159	23. 576
14............	18 27	23. 553			
17............	15 52	19. 727	−0. 0021	−0. 0021	19. 729
17............	18 43	19. 733	+0. 0593		
18............	15 59	18. 472	+0. 0524	+0. 0570	18. 414
20............	20 54	15. 700			
21	16 02	14. 571	+0. 0289	+0. 0289	14. 543
21............	19 19	14. 476			
23	16 22	12. 162	+0. 0405	+0. 0405	−12. 136
23............	19 33	− 12. 033			

Computation of observations for clock and instrumental corrections at Brest, France; Paris, France; and Greenwich, England.

NOTE.—A correction for rate is not applied to the individual results for clock-correction at Brest, Paris, and Greenwich; but its effect upon the finally-adopted clock-correction for each date is eliminated by the adoption of the mean of the right ascensions of the time-stars as the epoch of the mean clock-correction derived from them. The corrections due to collimation error and diurnal aberration are combined and applied as one correction instead of being applied separately, as at Cambridge and St. Pierre.

BREST.

(Observer, Francis Blake, jr.—An asterisk is affixed to the clock-corrections derived from stars of more than 60° N. declination.)

Dates.	Stars.	L. p.	Observed time of transit.	Corrections. Level.	Corrections. Azimuth	Corrections. Collimation and aberration.	Clock-time of meridian transit.	Right ascension.	Clock-correction.
1872.			h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	s.
July 1	τ Herculis	W.	16 15 52.31	−0.09	−0.01	−0.09	16 15 52.12	16 15 55.71	+3.59
	η Draconis	W.	22 14.90	− .13	+ .08	− .13	22 14.72	22 18.44	3.72*
	A Dracons	W.	28 14.45	− .15	+ .16	− .18	28 14.28	28 17.96	3.68*
	9 Camelop., L. C	W.	41 14.92	+ .05	− .36	+ .15	41 14.76	41 18.42	3.66*
	d Herculis	W.	16 56 51.29	− .05	− .05	− .08	16 56 51.11	16 56 54.82	3.71
	α^1 Herculis	E.	17 08 46.89	− .03	− .09	+ .04	17 08 46.81	17 08 50.50	3.69
	ψ^1 Draconis	E.	44 13.31	− .05	+ .21	+ .11	44 13.58	44 17.22	3.64*
	γ Draconis	E.	17 53 36.69	− .04	+ .03	+ .06	17 53 36.74	17 53 40.57	3.83
	22 Camelop., L. C	E.	18 04 38.89	+ .06	− .95	− .10	18 04 37.90	18 04 41.51	3.61*
	α Lyræ	E.	32 34.61	− .04	− .08	+ .04	32 34.53	32 38.39	3.86
	β Lyræ	E.	18 45 19.56	− .03	− .12	+ .04	18 45 19.45	18 45 23.26	3.81
July 3	β Bootis	E.	14 57 06.28	− .17	− .03	+ .09	14 57 06.17	14 57 08.97	2.80
	α Coronæ Borealis	E.	15 29 14.93	− .08	− .08	+ .08	15 29 14.85	15 29 17.67	2.82
	ζ Ursæ Minoris	E.	15 48 42.29	− .31	+ .48	+ .35	15 48 42.81	15 48 45.60	2.79*
	τ Herculis	E.	16 15 52.88	− .09	− .01	+ .10	16 15 52.88	16 15 55.78	2.90
	η Draconis	W.	22 15.60	− .14	+ .14	− .21	22 15.39	22 18.38	2.99*
	9 Camelop., L. C	W.	16 41 16.02	+ .07	− .63	+ .24	16 41 15.70	16 41 18.51	2.81*
	α^1 Herculis	W.	17 08 47.98	− .02	− .16	− .06	17 08 47.74	17 08 50.50	2.76
	β Draconis	W.	27 32.28	− .05	+ .03	− .03	27 32.23	27 34.86	2.63
	ω Draconis	W.	17 37 43.16	− .08	+ .27	− .12	17 37 43.23	17 37 45.71	2.48*
July 4	ζ Ursæ Minoris	W.	15 48 43.43	− .07	+ .29	− .34	15 48 43.31	15 48 45.51	2.20*
	η Draconis	W.	16 22 16.17	− .17	+ .06	− .15	16 22 15.91	16 22 18.35	2.44*
	A Draconis	W.	28 15.62	− .25	+ .12	− .19	28 15.30	28 17.85	2.55*
	η Herculis	W.	38 30.33	− .12	− .03	− .09	38 30.09	38 32.47	2.38
	d Herculis	W.	16 56 52.58	− .05	− .04	− .09	16 56 52.40	16 56 54.80	2.40
	α^1 Herculis	E.	17 08 48.22	− .06	− .06	+ .05	17 08 48.15	17 08 50.52	2.37
	β Draconis	E.	27 32.52	− .11	+ .01	+ .07	27 32.49	27 34.89	2.40
	ω Draconis	E.	17 37 43.42	− .21	+ .10	+ .11	17 37 43.42	17 37 45.78	2.36*
July 5	μ^1 Bootis	E.	15 19 39.05	− .14	+ .01	+ .05	15 19 38.97	15 19 40.92	1.95
	α Coronæ Borealis	E.	29 15.65	− .11	+ .01	+ .05	29 15.60	29 17.65	2.05
	ζ Ursæ Minoris	E.	48 43.61	− .37	− .06	+ .22	15 48 43.40	15 48 45.43	2.03*
	τ Herculis	E.	16 15 53.70	− .08	.00	+ .07	16 15 53.69	16 15 55.67	1.98
	η Draconis	E.	22 16.42	− .13	− .01	+ .10	22 16.38	22 18.33	1.95*
	A Draconis	E.	28 15.92	− .19	− .02	+ .13	28 15.84	28 17.82	1.98*
	9 Camelop., L. C	W.	41 16.85	+ .07	− .30	+ .18	41 16.80	41 18.60	1.80*
	κ Ophiuchi	W.	51 36.58	− .03	− .09	− .07	51 36.39	51 38.38	1.99
	d Herculis	W.	16 56 53.03	− .02	− .04	− .09	16 56 52.88	16 56 54.80	1.92
	α^1 Herculis	W.	17 08 48.58	.00	− .08	− .08	17 08 48.42	17 08 50.52	2.10
	ω Draconis	W.	17 37 44.02	.00	+ .13	− .20	17 37 42.95	17 37 45.68	1.73*
July 9	ε Serpentis	W.	15 44 27.61	+ .93	− .04	− .02	15 44 27.58	15 44 27.73	0.15
	ε Coronæ Borealis	W.	15 52 18.80	+ .04	− .02	− .02	15 52 18.80	15 52 18.92	0.12
	η Herculis	W.	16 38 32.30	+ .08	− .01	− .03	16 38 32.34	16 38 32.42	0.08
	9 Camelop., L. C	W.	41 18.92	− .06	− .13	+ .05	41 18.78	41 18.81	0.03*
	d Herculis	W.	16 56 54.75	+ .08	− .06	− .02	16 56 54.75	16 56 54.77	0.02
	α^1 Herculis	W.	17 08 50.45	+ .08	− .11	− .02	17 08 50.40	17 08 50.50	+0.10
	β Draconis	W.	27 34.66	+ .20	+ .02	− .03	27 34.85	27 34.84	−0.01
	ω Draconis	W.	37 45.18	+ .22	+ .19	− .06	37 45.53	37 45.59	+0.06*
	ψ^1 Draconis	E.	17 44 16.46	+0.22	+0.26	+0.02	17 44 16.96	17 44 17.01	+0.05*

Computation of observations for clock and instrumental corrections, &c.—Continued.

Dates.	Stars.	L. p.	Observed time of transit.	Corrections. Level.	Corrections. Azimuth.	Corrections. Collimation and aberration.	Clock-time of meridian transit.	Right ascension.	Clock-correction.
1872.			h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	s.
July 11	η Draconis	E.	16 22 18.82	—0.04	+0.07	+0.07	16 22 18.92	16 22 18.17	—0.75*
	A Draconis	E.	28 18.20	— .07	+ .14	+ .09	28 18.36	28 17.59	0.77*
	κ Ophiuchi	E.	51 39.23	+ .04	— .09	+ .03	51 39.21	51 38.37	0.84
	d Herculis	E.	16 56 55.63	+ .07	— .04	+ .04	16 56 55.70	16 56 54.76	0.94
	α^1 Herculis	E.	17 08 51.35	+ .05	— .08	+ .03	17 08 51.35	17 08 50.50	0.85
	Groom. 966, L. C	E.	22 36.17	— .14	— .45	— .12	22 35.46	22 34.55	0.91*
	β Draconis	E.	27 35.64	+ .11	+ .02	+ .05	27 35.82	27 34.82	1.00
	ω Draconis	E.	37 46.20	+ .20	+ .14	+ .01	37 46.63	37 45.53	1.10*
	ψ^1 Draconis	W.	17 44 17.59	+ .26	+ .19	— .20	17 44 17.84	17 44 16.94	0.90*
	α Lyræ	W.	18 32 39.17	+ .21	— .03	— .08	18 32 39.27	18 32 38.42	0.85
	50 Draconis	W.	50 34.57	+ .60	+ .25	— .24	50 35.18	50 34.23	0.95*
	ζ Aquilæ	W.	18 59 34.64	+ .14	— .08	— .06	18 59 34.64	18 59 33.58	1.06
July 12	d Herculis	W.	16 56 56.33	+ .12	— .02	— .02	16 56 56.41	16 56 54.75	1.66
	α^1 Herculis	W.	17 08 52.09	+ .07	— .04	— .02	17 08 52.10	17 08 50.49	1.61
	β Draconis	W.	27 36.37	+ .19	+ .01	— .03	27 36.54	27 34.81	1.73
	ω Draconis	W.	37 46.89	+ .16	+ .08	— .05	37 47.08	37 45.51	1.57*
	ψ^1 Draconis	E.	17 44 18.33	+ .14	+ .10	+ .06	17 44 18.63	17 44 16.91	1.72*
	β Lyrae	E.	18 45 24.90	+ .10	— .02	+ .02	18 45 25.09	18 45 23.31	1.69
	ζ Aquilæ	E.	59 35.26	+ .07	— .05	+ .02	59 35.30	18 59 33.59	1.71
	κ Aquilæ	E.	19 30 04.07	+ .03	— .06	+ .02	19 30 04.06	19 30 02.39	1.67
July 14	ε Serpentis	E.	15 44 29.89	— .03	— .02	+ .03	15 44 29.87	15 44 27.70	2.17
	ε Coronæ Borealis	E.	15 52 21.03	— .05	— .01	+ .03	15 52 21.00	15 52 18.87	2.13
	Groom. 2320	E.	16 06 03.64	— .12	+ .02	+ .08	16 06 03.62	16 06 01.48	2.14*
	τ Herculis	E.	15 57.53	— .04	.00	+ .04	15 57.53	15 55.53	2.00
	Draconis	E.	22 20.11	— .04	— .01	+ .06	22 20.14	22 18.09	2.05*
	A Draconis	E.	28 19.34	— .02	+ .02	+ .08	28 19.42	28 17.47	1.95*
	9 Camelop., L. C	E.	41 21.69	— .02	— .05	— .07	41 21.55	41 19.07	2.48*
	κ Ophiuchi	E.	51 40.47	+ .02	— .01	+ .03	51 40.51	51 38.35	2.16
	d Herculis	E.	16 56 56.79	+ .02	— .01	+ .04	16 56 56.84	16 56 54.73	2.11
	α^1 Herculis	W.	17 08 52.71	+ .06	— .08	— .06	17 08 52.63	17 08 50.49	2.14
	β Draconis	W.	27 36.83	+ .16	+ .02	— .09	27 36.92	27 34 78	2.14
	ω Draconis	W.	37 47.32	+ .30	+ .13	— .16	37 47.59	37 45.45	2.14*
	ψ^1 Draconis	W.	17 44 18.79	+ .29	+ .18	— .19	17 44 19.07	17 44 16.84	2.23*
	α Lyræ	W.	18 32 40.47	+. 16	— .03	— .07	18 32 40.53	18 32 38.42	2.11
	β Lyræ	W.	18 45 25.50	+ .15	— .04	— .07	18 45 25.54	18 45 23.31	2.23
	δ Draconis	E.	19 12 36.41	+ .16	+ .19	+ .08	19 12 36.84	19 36 34.61	2.23*
	δ Aquilæ	E.	19 07.01	+ .06	— .16	+ .03	19 06.94	6 04.70	2.24
	γ Aquilæ	E.	40 14.68	+ .06	— .14	+ .03	40 14.63	14 12.47	2.16
	α Aquilæ	E.	44 36.52	+ .04	— .14	+ .03	44 36.45	36 34.30	2.15
	ε Draconis	E.	19 48 41.18	+ .12	+ .24	+ .08	19 48 41.62	19 41 39.36	2.26*
July 17	ε Coronæ Borealis	E.	15 52 21.47	+ .03	+ .03	+ .10	15 52 21.63	15 52 18.84	2.79
	δ Ophiuchi	E.	16 07 42.61	+ .01	+ .07	+ .09	16 7 42.78	16 07 39.97	2.81
	τ Herculis	E.	15 58.09	+ .04	.00	+ .13	15 58.26	15 55.48	2.78
	η Draconis	E.	22 20.50	+ .08	— .04	+ .18	22 20.72	22 17.99	2.73*
	A Draconis	E.	23 19.91	+ .15	— .08	+ .24	28 20.22	28 17.33	2.89*
	9 Camelop., L. C	E.	41 22.36	— .07	+ .19	— .21	41 22.27	41 19.24	3.03*
	κ Ophiuchi	W.	51 41.18	+ .06	— .01	— .12	51 41.11	51 38.33	2.78
	d Herculis	W.	16 56 57.46	+ .10	.00	— .14	16 56 57.42	16 56 54.70	2.72
	α^1 Herculis	W.	17 08 53.29	+ .09	— .01	— .12	17 08 53.25	17 08 50.47	2.78
	β Draconis	W.	27 37.57	+ .16	.00	— .19	27 37.54	27 34.74	2.80
	ω Draconis	W.	37 48.12	+ .24	+ .01	— .32	37 48.05	37 45.35	2.70*
	ψ^1 Draconis	W.	17 44 19.66	+ .26	+ .01	— .37	17 44 19.56	17 44 16.73	2.83*
	η Serpentis	W.	18 14 46.07	+ .05	— .01	— .11	18 14 46.00	18 14 43.22	2.78
	1 Aquilæ	W.	18 23 19.45	+ .06	— .01	— .12	18 28 19.38	18 28 16 57	2.81
	α Lyræ	W.	18 32 41.13	+ .15	.00	— .15	18 32 41.13	18 32 38.42	2.71
	β Lyræ	W.	45 26.18	+ .19	.00	— .14	45 26.23	45 23.32	2.91
	50 Draconis	W.	50 36.83	+ .65	+ .02	— .45	50 37.05	50 34.06	2.97*
	ζ Aquilæ	W.	18 59 36.52	+0.13	—0.01	—0.12	18 59 36.52	18 59 33.62	—2.90

Computation of observations for clock and instrumental corrections, &c.—Continued.

Dates.	Stars.	L. p.	Observed time of transit.	Corrections. Level.	Corrections. Azimuth.	Corrections. Collimation and aberration.	Clock-time of meridian transit.	Right ascension.	Clock-correction.
1872.			h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	s.
July 18	κ Ophiuchi	E.	16 51 41.23	+0.03	+0.14	+0.01	16 51 41.41	16 51 38.33	−3.08
	d Herculis	E.	16 56 57.55	+ .05	+ .06	+ .02	16 56 57.68	16 56 54.69	2.99
	a¹ Herculis	E.	17 8 53.35	+ .03	+ .12	+ .01	17 8 53.51	17 8 50.47	3.04
	β Draconis	E.	27 37.54	+ .10	− .02	+ .02	27 37.64	27 34.72	2.92
	ω Draconis	E.	37 48.33	+ .15	− .21	+ .04	37 48.31	37 45.31	3.00*
	ψ¹ Draconis	E.	17 44 19.90	+ .17	− .28	+ .05	17 44 19.84	17 44 16.69	3.15*
	η Serpentis	W.	18 14 46.44	+ .06	− .16	− .04	18 14 46.30	18 14 43.22	3.08
	1 Aquilæ	W.	28 19.74	+ .05	− .17	− .04	28 19.58	28 16.58	3.00
	α Lyræ	W.	32 41.42	+ .10	− .04	− .05	32 41.43	32 38.41	3.02
	β Lyræ	W.	45 26.45	+ .13	− .06	− .05	45 26.47	45 23.32	3.15
	ζ Aquilæ	W.	18 59 36.72	+ .13	− .12	− .04	18 59 36.69	18 59 33.63	3.06
	δ Draconis	W.	19 12 37.55	+ .33	− .15	− .11	19 12 37.62	19 12 34.57	3.05*
	δ Aquilæ	E.	19 7.63	+ .07	+ .13	+ .01	19 7.84	19 4.73	3.11
	γ Aquilæ	E.	40 15.34	+ .08	+ .11	+ .01	40 15.54	40 12.51	3.03
	ε Draconis	E.	19 48 42.44	+ .30	− .19	+ .04	19 48 42.59	19 48 39.35	3.24*
July 19	κ Ophiuchi	E.	16 51 41.26	− .02	+ .04	− .01	16 51 41.27	16 51 38.32	2.95
	d Herculis	E.	16 56 57.74	− .04	+ .02	− .01	16 56 57.71	16 56 54.68	3.03
	a¹ Herculis	E.	17 8 53.45	.00	+ .04	− .01	17 8 53.48	17 8 50.46	3.02
	β Draconis	E.	27 37.80	+ .03	− .01	− .01	27 37.81	27 34.70	3.11
	ω Draconis	E.	37 48.36	+ .02	− .06	− .02	37 48.30	37 45.28	3.02*
	ψ¹ Draconis	E.	17 44 19.69	− .05	− .08	− .02	17 44 19.54	17 44 16.65	2.89*
	η Serpentis	W.	18 14 46.56	+ .02	− .23	− .02	18 14 46.33	18 14 43.22	3.11
	1 Aquilæ	W.	28 19.81	+ .03	− .25	− .02	28 19.57	28 16.58	2.99
	α Lyræ	W.	32 41.38	+ .06	− .06	− .03	32 41.35	32 38.41	2.94
	ζ Aquilæ	W.	18 59 36.71	+ .07	− .17	− .02	18 59 36.59	18 59 33.63	2.96
	δ Draconis	W.	19 12 37.22	+ .25	+ .25	− .05	19 12 37.67	19 12 34.56	3.11*
	τ Draconis	W.	18 6.64	+ .33	+ .39	− .07	18 7.29	18 4.29	3.00*
	κ Aquilæ	W.	30 5.65	+ .06	− .23	− .02	30 5.46	30 2.46	3.00
	α Aquilæ	W.	19 44 37.43	+ .11	− .18	− .02	19 44 37.34	19 44 34.35	2.99
July 20	ζ Ophiuchi	W.	16 30 11.60	.00	+ .14	− .04	16 30 11.70	16 30 8.44	3.26
	κ Ophiuchi	W.	51 41.48	− .01	+ .10	− .04	51 41.53	51 38.32	3.21
	d Herculis	W.	16 56 57.88	+ .01	+ .05	− .05	16 56 57.89	16 56 54.67	3.22
	a¹ Herculis	W.	17 8 53.61	+ .07	+ .09	− .04	17 8 53.73	17 8 50.46	3.27
	β Draconis	W.	27 37.93	+ .17	− .02	− .07	27 38.01	27 34.69	3.32
	ω Draconis	W.	37 48.61	+ .20	− .16	− .12	37 48.53	37 45.24	3.29*
	ψ¹ Draconis	W.	17 44 19.87	+ .24	− .21	− .14	17 44 19.76	17 44 16.61	3.15*
	η Serpentis	E.	18 14 46.38	+ .02	+ .13	+ .02	18 14 46.55	18 14 43.22	3.33
	1 Aquilæ	E.	28 19.74	+ .01	+ .14	+ .02	28 19.91	28 16.58	3.33
	α Lyræ	E.	32 41.41	+ .04	+ .05	+ .02	32 41.52	32 38.41	3.11
	β Lyræ	E.	18 45 26.47	+ .03	+ .07	+ .02	18 45 26.59	18 45 23.32	3.27
	δ Draconis	E.	19 12 37.78	+ .20	− .20	+ .04	19 12 37.82	19 12 34.55	3.27*
	τ Draconis	E.	18 7.51	+ .28	− .34	+ .05	18 7.50	18 4.28	3.22*
	γ Aquilæ	E.	40 15.57	+ .07	+ .15	+ .02	40 15.81	40 12.53	3.28
	α Aquilæ	E.	44 37.41	+ .07	+ .15	+ .02	44 37.65	44 34.36	3.29
	β Aquilæ	E.	19 49 6.70	+ .07	+ .16	+ .02	19 49 6.95	19 49 3.62	3.33
July 21	η Serpentis	W.	18 14 46.78	+ .01	+ .08	− .22	18 14 46.65	18 14 43.22	3.43
	1 Aquilæ	W.	28 20.21	+ .04	+ .08	− .23	28 20.10	28 16.58	3.52
	α Lyræ	W.	32 42.01	+ .08	+ .02	− .29	32 41.82	32 38.40	3.42
	β Lyræ	W.	45 26.95	+ .09	+ .03	− .26	45 26.81	45 23.32	3.49
	ζ Aquilæ	W.	18 59 37.23	+ .07	+ .06	− .23	18 59 37.13	18 59 33.64	3.49
	δ Draconis	W.	19 12 38.25	+ .20	− .08	− .58	19 12 37.79	19 12 34.54	3.25*
	δ Aquilæ	E.	19 7.99	+ .05	− .03	+ .20	19 8.21	19 4.75	3.46
	γ Aquilæ	E.	40 15.68	+ .03	− .03	+ .20	40 15.88	40 12.53	3.35
	ε Draconis	E.	48 42.25	+ .10	+ .04	+ .57	48 42.96	48 39.33	3.63*
	τ Aquilæ	E.	19 57 58.50	+ .03	− .03	+ .20	19 57 58.70	19 57 55.30	3.40
	ε Delphini	E.	20 27 10.97	+ .06	− .02	+ .20	20 27 11.21	20 27 7.90	3.31
	ε Cygni	E.	20 37 9.26	+0.11	−0.00	+0.27	20 37 9.64	20 37 6.35	−3.29

Computation of observations for clock and instrumental corrections, &c.—**Continued.**

Dates.	Stars.	L. p.	Observed time of transit.			Corrections. Level.	Corrections. Azimuth.	Corrections. Collimation and aberration.	Clock-time of meridian transit.			Right ascension.			Clock-correction.
1872.			*h.*	*m.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*s.*
July 21	γ Cygni	E.	20	52	29.19	+0.10	—0.01	+0.26	20	52	29.54	20	52	26.26	—3.28
	β Cephei	E.	21	27	6.12	+ .22	+ .04	+ .57	21	27	6.95	21	27	3.36	3.59*
July 22	a¹ Herculis	E.	17	8	54.03	— .03	+ .04	+ .13	17	8	54.17	17	8	50.44	3.73
	β Draconis	E.		27	38.09	+ .05	— .01	+ .21		27	38.34		27	34.65	3.69
	ω Draconis	E.		37	48.46	+ .10	— .07	+ .35		37	48.84		37	45.17	3.67*
	ψ¹ Draconis	E.	17	44	19.77	+ .08	— .09	+ .42	17	44	20.18	17	44	16.52	3.66*
	η Serpentis	E.	18	14	46.75	+ .01	+ .06	+ .13	18	14	46.95	18	14	43.22	3.73
	1 Aquilæ	E.		28	20.18	— .02	+ .06	+ .13		28	20.35		28	16.58	3.77
	ι Lyræ	E.		32	41.78	+ .04	— .05	+ .16		32	41.93		32	38.40	3.53
	β Lyræ	W.		45	27.28	+ .04	— .07	— .19		45	27.06		45	23.32	3.74
Set I	ζ Aquilæ	W.	18	59	37.50	+ .04	— .13	— .16	18	59	37.25	18	59	33.64	3.61
	δ Draconis	W.	19	12	38.19	+ .19	+ .19	— .40	19	12	38.17	19	12	34.52	3.65*
	δ Aquilæ	W.		19	8.79	+ .06	— .16	— .16		19	8.53		19	4.76	3.77
	κ Aquilæ	W.		30	6.45	+ .06	— .12	— .16		30	6.23		30	2.48	3.75
	γ Aquilæ	W.		40	16.37	+ .08	— .09	— .16		40	16.20		40	12.54	3.66
	ε Draconis	W.		48	43.04	+ .26	+ .15	— .45		48	43.02		48	39.32	3.70*
	τ Aquilæ	W.	19	57	59.21	+ .07	— .09	— .16	19	57	59.03	19	57	55.30	3.73
	ε Delphini	W.	20	27	11.78	+ .08	— .09	— .16	20	27	11.61	20	27	7.91	3.70
	α Cygni	W.	20	37	10.16	+ .19	— .01	— .22		37	10.12		37	6.36	3.76
July 22	μ Aquarii	W.		45	51.20	+ .08	— .16	— .06		45	51.06		45	47.13	3.93
	ν Cygni	W.		52	30.04	+ .14	— .03	— .08		52	30.07		52	26.27	3.80
	σ₂ Ursæ Majoris, L. C.	W.	20	59	8.55	— .12	— .45	+ .15	20	59	8.13	20	59	4.24	3.89*
	ξ Cygni	W.	21	7	35.16	+ .11	— .07	— .07	21	7	35.13	21	7	31.36	3.77
	1 Draconis, L. C.	W.		18	38.36	— .47	—1.04	+ .41		18	37.26		18	33.00	4.26*
	β Cephei	W.		27	6.91	+ .29	+0.21	— .17		27	7.24		27	3.38	3.86*
	11 Cephei	E.		40	8.90	+ .20	+ .17	+ .09		40	9.36		40	5.70	3.66*
	α Aquarii	E.	21	59	18.21	+ .06	— .11	+ .03	21	59	18.19	21	59	14.50	3.69
	θ Aquarii	E.	22	10	10.40	+ .05	— .13	+ .03	22	10	10.35	22	10	6.66	3.69
Set II.	9 Draconis, L. C.	E.		24	11.35	— .19	— .53	— .13		24	10.50		24	6.50	4.00*
	ζ Pegasi	E.		35	10.18	+ .06	— .10	+ .03		35	10.17		35	6.49	3.68
	ι Cephei	E.		45	13.68	+ .22	+ .13	+ .07		45	14.10		45	10.17	3.93*
	α Pegasi	W.	22	58	28.70	+ .08	— .11	— .06	22	58	28.62	22	58	24.85	3.77
	ο Cephei	W.	23	13	28.66	+ .23	+ .16	— .15	23	13	28.90	23	13	25.07	3.83*
	λ Draconis, L. C.	W.		23	50.24	— .13	— .49	+ .17		23	49.79		23	45.89	3.90*
	ι Piscium	W.		33	27.52	+ .07	— .13	— .06		33	27.40		33	23.62	3.78
	ω Piscium	W.	23	52	49.72	+ .07	— .13	— .06	23	52	49.60	23	52	45.82	3.78
	α Andromedæ	W.	0	1	51.65	+ .09	— .07	— .07	0	1	51.60	0	1	47.89	3.71
	γ Pegasi	W.	0	6	44.02	+ .07	— .11	— .06	0	6	43.92	0	6	40.15	3.77
July 23	κ Ophiuchi	W.	16	51	42.53	— .07	— .07	— .10	16	51	42.29	16	51	38.30	3.99
	d Herculis	W.	16	56	58.92	— .09	— .03	— .12	16	56	58.68	16	56	54.64	4.04
	a¹ Herculis	W.	17	8	54.71	— .06	— .06	— .10	17	8	54.49	17	8	50.44	4.05
	η Serpentis	W.	18	14	47.52	— .01	— .08	— .10	18	14	47.33	18	14	43.22	4.11
	1 Aquilæ	W.		28	20.81	— .01	— .09	— .10		28	20.61		28	16.59	4.02
	α Lyræ	W.		32	42.49	— .04	— .02	— .12		32	42.31		32	38.39	3.92
	β Lyræ	W.		45	27.52	— .03	— .03	— .12		45	27.34		45	23.31	4.03
	50 Draconis	W.		50	38.11	— .07	+ .19	— .38		50	37.85		50	33.89	3.96*
	ζ Aquilæ	W.	18	59	37.88	— .01	+ .05	— .10	18	59	37.82	18	59	33.64	4.18
	δ Draconis	W.	19	12	38.84	— .02	— .07	— .25	19	12	38.50	19	12	34.51	3.99*
	τ Draconis	E.		18	8.07	.00	— .12	+ .24		18	8.19		18	4.21	3.98*
	κ Aquilæ	E.		30	6.42	— .01	+ .07	+ .07		30	6.55		30	2.49	4.06
	γ Aquilæ	E.	19	40	16.53	.00	+ .05	+ .07	19	40	16.65	19	40	12.54	4.11
	ε Cygni	E.	20	37	10.24	—0.02	+0.01	+0.10	20	37	10.33	20	37	6.37	—3.96

Computation of observations for clock and instrumental corrections, &c.—Continued.

PARIS.

Dates.	Stars.	L. p.	Observed time of transit.			Corrections. Level.	Azimuth.	Collimation and aberration.	Clock-time of meridian transit.			Right ascension.			Clock-correction.
1872.			h.	m.	s.	s.	s.	s.	h.	m.	s.	h.	m.	s.	s.
Aug. 16	ψ^1 Draconis	W.	17	44	17.22	+0.23	+0.37	—1.16	17	44	16.66	17	44	15.13	—1.53*
	η Serpentis	W.	18	14	45.07	+ .08	— .22	—0.36	18	14	44.57	18	14	43.09	1.48
	1 Aquilæ	W.		28	18.48	+ .08	— .24	— .36		28	17.96		28	16.49	1.47
	α Lyræ	W.		32	39.86	+ .21	— .07	— .46		32	39.54		32	38.13	1.41
	β Lyræ	W.		45	24.98	+ .17	— .09	— .43		45	24.63		45	23.11	1.52
	50 Draconis	W.		50	34.50	+ .47	+ .50	—1.40		50	34.07		50	32.61	1.46*
	ζ Aquilæ	E.	18	59	34.77	+ .10	— .11	+0.34	18	59	35.10	18	59	33.56	1.44
	δ Draconis	E.	19	12	34.02	+ .29	+ .16	+ .85	19	12	35.32	19	12	33.86	1.46*
	τ Draconis	E.		18	3.10	+ .38	+ .27	+1.13		18	4.88		18	3.31	1.57*
	κ Aquilæ	E.		30	3.81	+ .07	— .16	+0.33		30	4.05		30	2.51	1.54
	γ Aquilæ	E.		40	13.73	+ .08	— .12	+ .33		40	14.02		40	12.55	1.47
	α Aquilæ	E.		44	35.55	+ .08	— .12	+ .33		44	35.84		44	34.40	1.44
	ε Draconis	E.	19	48	38.87	+ .26	+ .20	+ .96	19	48	40.29	19	48	38.79	1.50*
	3 Ursæ Majoris, L. C.	E.	20	0	4.65	— .12	— .46	— .91	20	0	3.16	20	0	1.78	1.38*
	ε Delphini	E.		27	9.26	+ .07	— .12	+ .33		27	9.54		27	8.03	1.51
	α Cygni	E.	20	37	7.18	+ .11	— .02	+ .46	20	37	7.73	20	37	6.40	1.33
Aug. 17	ψ^1 Draconis	E.	17	44	15.93	+ .13	+ .12	+ .19	17	44	16.37	17	44	15.06	1.31*
	η Serpentis	E.	18	14	44.43	+ .04	— .07	+ .06	18	14	44.46	18	14	43.08	1.38
	1 Aquilæ	E.		28	17.84	+ .05	— .08	+ .06		28	17.87		28	16.48	1.39
	α Lyræ	E.		32	39.15	+ .12	— .02	+ .07		32	39.32		32	38.11	1.21
	β Lyræ	E.		45	24.23	+ .13	— .03	+ .07		45	24.40		45	23.10	1.30
	50 Draconis	E.		50	33.27	+ .39	+ .16	+ .22		50	34.04		50	32.54	1.50*
	ζ Aquilæ	W.	18	59	34.98	+ .11	— .06	— .09	18	59	34.94	18	59	33.55	1.39
	δ Draconis	W.	19	12	34.98	+ .33	+ .09	— .22	19	12	35.18	19	12	33.83	1.35*
	Piazzi VII, 67, L. C	W.		17	33.39	— .17	— .26	+ .24		17	33.20		17	31.84	1.36*
	κ Aquilæ	W.		30	3.98	+ .07	— .09	— .09		30	3.87		30	2.51	1.36
	γ Aquilæ	W.		40	13.91	+ .10	— .07	— .09		40	13.85		40	15.55	1.30
	α Aquilæ	W.		44	35.74	+ .10	— .07	— .09		44	35.68		44	34.40	1.28
	ε Draconis	W.		48	39.90	+ .36	+ .11	— .25		48	40.12		48	38.75	1.37*
	τ Aquilæ	W.	19	57	56.74	+ .11	— .07	— .09	19	57	56.69	19	57	55.36	1.33
	α^2 Capricorni	W.	20	11	0.91	+ .08	— .09	— .09	20	11	0.81	20	11	59.45	1.36
	π Capricorni	W.		20	3.46	+ .07	— .10	— .09		20	3.34		20	2.05	1.29
	ε Delphini	W.		27	9.36	+ .14	— .07	— .09		27	9.34		27	8.03	1.31
	α Cygni	W.	20	37	7.60	+ .23	— .01	— .12	20	37	7.70	20	37	6.40	1.30
Aug. 18	ψ^1 Draconis	W.	17	44	16.38	+ .19	+ .16	—0.33	17	44	16.40	17	44	14.99	1.41*
	η Serpentis	W.	18	14	44.63	+ .03	— .10	— .10	18	14	44.46	18	14	43.07	1.39
	1 Aquilæ	W.		28	17.98	+ .03	— .10	— .10		28	17.81		28	16.47	1.34
	α Lyræ	W.		32	39.39	+ .08	— .03	— .13		32	39.31		32	38.09	1.22
	β Lyræ	W.		45	24.48	+ .12	— .04	— .12		45	24.44		45	23.08	1.36
	50 Draconis	W.		50	33.60	+ .41	+ .21	— .39		50	33.83		50	32.47	1.36*
	ζ Aquilæ	W.	18	59	34.92	+ .10	— .07	— .10	18	59	34.85	18	59	33.54	1.31
	δ Draconis	E.	19	12	34.66	+ .25	+ .04	+ .18	19	12	35.13	19	12	33.79	1.34*
	κ Aquilæ	E.		30	3.78	+ .06	— .04	+ .07		30	3.87		30	2.50	1.37
	γ Aquilæ	E.		40	13.78	+ .08	— .03	+ .07		40	13.90		40	12.54	1.36
	α Aquilæ	E.		44	35.59	+ .07	— .03	+ .07		44	35.70		44	34.39	1.31
	ε Draconis	E.	19	48	39.57	+ .20	+ .05	+ .20	19	48	40.02	19	48	38.72	1.30*
	3 Ursæ Majoris, L. C	E.	20	0	3.47	— .09	— .11	— .20	20	0	3.07	20	0	1.87	1.20*
	α^2 Capricorni	E.		11	0.74	+ .04	— .04	+ .07		11	0.81		11	59.45	1.36
	κ Capricorni	E.		20	3.32	+ .03	— .04	+ .07		20	3.38		20	2.05	1.33
	ε Delphini	E.		27	9.23	+ .07	— .03	+ .07		27	9.34		27	8.03	1.31
	α Cygni	E.	20	37	7.43	+ .12	.00	+ .10	20	37	7.65	20	37	6.40	1.25
Aug. 19	ψ^1 Draconis	E.	17	44	16.17	+ .05	+ .07	+ .22	17	44	16.51	17	44	14.93	1.58*
	1 Aquilæ	E.	18	28	17.90	+ .01	— .05	+ .07	18	28	17.93	18	28	16.46	1.47
	α Lyræ	E.		32	39.30	+ .02	— .01	+ .09		32	39.40		32	38.08	1.32
	β Lyræ	E.		45	24.35	+ .01	— .02	+ .0		45	24.42		45	23.07	1.35
	50 Draconis	E.	18	50	33.38	—0.03	+0.10	+0.27	18	50	33.72	18	50	32.41	—1.31*

Computation of observations for clock and instrumental corrections, &c.—**Continued.**

PARIS.

Dates.	Stars.	L. p.	Observed time of transit.			Corrections. Level.	Azimuth.	Collimation and aberration.	Clock-time of meridian transit.			Right ascension.			Clock-correction.
1872.			*h.*	*m.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*s.*
Aug. 19	ζ Aquilæ	E.	18	59	34.91	+0.01	−0.03	+0.07	18	59	34.96	18	59	33.53	−1.43
	δ Draconis	W.	19	12	35.32	+ .11	+ .05	− .25	19	12	35.23	19	12	33.75	1.48*
	Piazzi VII, 67, L. C.	W.		17	33.18	− .04	− .13	+ .27		17	33.28		17	31.95	1.33*
	κ Aquilæ	W.		30	4.04	+ .01	− .05	− .10		30	3.90		30	2.50	1.40
	γ Aquilæ	W.		40	13.98	+ .03	− .03	− .10		40	13.88		40	12.54	1.34
	α Aquilæ	W.		44	35.82	+ .04	− .04	− .10		44	35.72		44	34.39	1.33
	ε Draconis	W.		48	40.16	+ .18	+ .06	− .28		48	40.12		48	38.68	1.44*
	τ Aquilæ	W.	19	57	56.88	+ .06	− .04	− .10	19	57	56.80	19	57	55.36	1.44
	α² Capricorni	W.	20	11	0.97	+ .03	− .05	− .10	20	11	0.85	20	11	59.45	1.40
	π Capricorni	W.		20	3.61	+ .03	− .05	− .10		20	3.49		20	2.05	1.44
	ε Delphini	W.		27	9.48	+ .06	− .03	− .10		27	9.41		27	8.03	1.38
	α Cygni	W.	20	37	7.82	+ .11	− .01	− .14	20	37	7.78	20	37	6.39	1.39
Aug. 20	η Serpentis	W.	18	14	44.84	− .02	− .13	− .10	18	14	44.59	18	14	43.05	1.54
	1 Aquilæ	W.		28	18.28	− .01	− .14	− .10		28	18.03		28	16.45	1.58
	α Lyræ	W.		32	39.73	− .01	− .04	− .12		32	39.56		32	38.06	1.50
	β Lyræ	W.		45	24.82	+ .01	− .05	− .11		45	24.67		45	23.06	1.61
	50 Draconis	W.		50	34.02	+ .04	+ .28	− .37		50	33.97		50	32.33	1.64*
	ζ Aquilæ	W.	18	59	35.21	− .01	− .10	− .10	18	59	35.00	18	59	33.52	1.48
	δ Draconis	E.	19	12	34.97	− .11	+ .08	+ .17	19	12	35.11	19	12	33.71	1.40*
	Piazzi VII, 67, L. C.	E.		17	33.79	+ .06	− .24	− .19		17	33.42		17	32.01	1.41*
	γ Aquilæ	E.		40	14.15	− .03	− .06	+ .07		40	14.13		40	12.53	1.60
	α Aquilæ	E.		44	35.95	− .03	− .07	+ .07		44	35.92		44	34.38	1.54
	ε Draconis	E.	19	48	39.94	− .09	+ .11	+ .19	19	48	40.15	19	48	38.64	1.51*
	ζ Ursæ Majoris, L. C.	E.	20	0	3.76	+ .04	− .25	− .19	20	0	3.36	20	0	1.97	1.39*
	α² Capricorni	E.		11	1.07	− .01	− .09	+ .07		11	1.04		11	59.45	1.59
	ε Delphini	E.		27	9.55	− .02	− .06	+ .07		27	9.54		27	8.03	1.51
	α Cygni	E.	20	37	7.80	−0.06	−0.01	+0.09	20	37	7.82	20	37	6.38	−1.44

GREENWICH.

Dates.	Stars.	L. p.	Observed time of transit.			Level.	Azimuth.	Collimation and aberration.	Clock-time of meridian transit.			Right ascension.			Clock-correction.
Aug. 28	η Serpentis	E.	18	14	41.29	−0.06	−0.30	+0.32	18	12	41.25	18	14	42.95	+1.70
	1 Aquilæ	E.		28	14.66	− .05	− .32	+ .32		28	14.61		28	16.36	1.75
	α Lyræ	E.		32	35.99	− .11	− .10	+ .41		32	36.19		32	37.90	1.71
	β Lyræ	E.		45	21.12	− .09	− .14	+ .38		45	21.27		45	22.92	1.65
	ζ Aquilæ	E.	18	59	31.71	− .06	− .23	+ .33	18	59	31.75	18	59	33.43	1.68
	δ Draconis	E.	19	12	30.90	− .16	+ .26	+ .84	19	12	31.84	19	12	33.36	1.52*
	τ Draconis	W.		18	2.00	− .11	+ .40	−1.10		18	1.19		18	2.64	1.45*
	κ Aquilæ	W.		30	1.34	− .02	− .27	−0.32		30	0.73		30	2.43	1.70
	γ Aquilæ	W.		40	11.17	− .04	− .21	− .33		40	10.59		40	12.47	1.88
	α Aquilæ	W.		44	33.20	− .03	− .22	− .32		44	32.63		44	34.33	1.70
	ε Draconis	W.		48	37.39	− .12	+ .29	− .94		48	36.62		48	38.31	1.69*
	τ Aquilæ	W.	19	57	54.18	− .03	− .22	− .32	19	57	53.61	19	57	55.31	1.70
	ε Delphini	W.	20	27	6.94	− .07	− .21	− .33	20	27	6.33	20	27	7.99	1.66
	α Cygni	W.	20	37	5.05	− .15	− .05	− .45	20	37	4.40	20	37	6.30	1.90
Aug. 30	1 Aquilæ	W.	18	28	15.08	− .04	− .63	+ .18	18	28	14.59	18	28	16.34	1.75
	α Lyræ	W.		32	35.90	− .09	− .21	+ .22		32	35.82		32	37.86	2.04
	β Lyræ	W.		45	20.82	− .07	− .27	+ .21		45	20.69		45	22.89	[2.20]
	50 Draconis	W.		50	28.12	− .26	+1.15	+ .69		50	29.70		50	31.58	1.88*
	ζ Aquilæ	W.	18	59	31.96	− .07	−0.46	+ .18	18	59	31.61	18	59	33.41	1.80
	δ Draconis	W.	19	12	30.57	− .24	+ .52	+ .46	19	12	31.31	19	12	33.27	1.96*
	κ Aquilæ	E.		30	1.39	− .05	− .52	− .21		30	0.61		30	2.41	1.80
	γ Aquilæ	E.		40	11.25	− .07	− .41	− .21		40	10.56		40	12.45	1.89
	α Aquilæ	E.		44	33.13	− .06	− .42	− .21		44	32.44		44	34.31	1.87
	ε Draconis	E.		48	36.66	− .18	+ .56	− .59		48	36.45		48	38.22	1.77*
	τ Aquilæ	E.	19	57	54.13	− .05	− .43	− .21	19	57	53.44	19	57	55.30	1.86
	κ Cephei	E.	20	13	11.33	− .30	+1.21	− .93	20	13	11.31	20	13	12.98	1.67*
	ε Delphini	E.		27	6.70	− .05	−0.40	− .21		27	6.04		27	7.98	1.94
	α Cygni	E.	20	37	4.79	−0.09	−0.10	−0.29	20	37	4.31	20	37	6.28	+1.97

Computation of observations for clock and instrumental corrections, &c.—Continued.

GREENWICH.

Dates.	Stars.	L. p.	Observed time of transit.	Corrections. Level.	Corrections. Azimuth.	Corrections. Collimation and aberration.	Clock-time of meridian transit.	Right ascension.	Clock-correction.
1872.			*h. m. s.*	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*s.*
Aug. 31	1 Aquilæ	E.	18 28 14.87	—0.08	—0.40	—0.15	18 28 14.24	18 28 16.33	+2.09
	α Lyræ	E.	32 36.16	— .21	— .13	— .19	32 35.63	32 37.84	2.21
	β Lyræ	E.	45 21.27	— .19	— .17	— .17	45 20.74	45 22.87	2.13
	50 Draconis	E.	50 29.74	— .58	+ .73	— .58	50 29.31	50 31.50	2.19*
	ζ Aquilæ	E.	18 59 31.72	— .13	— .29	— .15	18 59 31.15	18 59 33.40	2.25
	δ Draconis	E.	19 12 31.48	— .37	+ .33	— .38	19 12 31.06	19 12 33.22	2.16*
	α Aquilæ	W.	32 32.24	— .08	— .36	+ .15	32 31.95	32 34.31	2.36
	ε Draconis	W.	48 35.52	— .27	+ .47	+ .43	48 36.15	48 38.17	2.02
	τ Aquilæ	W.	19 57 53.52	— .07	— .37	+ .15	19 57 53.23	19 57 55.29	2.06
	κ Cephei	W.	20 13 9.60	— .45	+1.03	+ .67	20 13 10.85	20 13 12.91	2.06*
	π Capricorni	W.	20 0.46	— .05	—0.51	+ .15	20 0.05	20 2.00	1.95
	ε Delphini	W.	27 6.00	— .10	— .34	+ .15	27 5.71	27 7.97	2.26
	α Cygni	W.	37 3.82	— .14	— .08	+ .21	37 3.81	37 6.27	2.46
	γ Cygni	W.	20 52 23.91	— .11	— .13	+ .19	20 52 23.86	20 52 26.30	2.44
Sept. 3	α Ophiuchi	W.	17 28 57.35	— .06	— .31	+ .22	17 28 57.20	17 28 0.92	3.72
	ω Draconis	W.	37 38.45	— .21	+ .40	+ .59	37 39.23	37 42.95	3.72*
	ψ^1 Draconis	W.	17 44 9.31	— .23	+ .56	+ .69	17 44 10.33	17 44 13.86	3.53*
	η Serpentis	W.	18 14 39.51	— .14	— .39	+ .21	18 14 39.19	18 14 42.87	3.68
	1 Aquilæ	W.	28 12.98	— .03	— .42	+ .21	28 12.74	28 16.29	3.55
	α Lyræ	W.	32 33.88	— .08	— .14	+ .27	32 33.93	32 37.77	3.84
	β Lyræ	W.	45 18.99	— .08	— .18	+ .25	45 18.98	45 22.81	3.83
	ζ Aquilæ	E.	18 59 30.13	— .08	— .13	— .25	18 59 29.67	18 59 33.35	3.68
	δ Draconis	E.	19 12 30.14	— .25	+ .14	— .63	19 12 29.40	19 12 33.07	3.67*
	ε Draconis	E.	17 59.33	— .29	+ .25	— .83	17 58.46	17 2.25	3.79*
	γ Aquilæ	E.	40 9.13	— .07	— .12	— .25	40 8.69	40 12.41	3.72
	α Aquilæ	E.	19 44 31.00	— .07	— .14	— .24	19 44 30.55	19 44 34.27	3.72
Sept. 4	1 Aquilæ	E.	18 28 13.25	— .08	— .65	— .21	18 28 12.31	18 28 16.28	3.97
	α Lyræ	E.	32 34.35	— .17	— .21	— .27	32 33.70	32 37.75	4.05
	β Lyræ	E.	45 19.26	— .12	— .28	— .25	45 18.61	45 22.79	4.18
	ζ Aquilæ	E.	18 59 29.98	— .08	— .47	— .22	18 59 29.21	18 59 33.34	4.13
	δ Draconis	E.	19 12 29.17	— .22	+ .53	— .55	19 12 28.93	19 12 33.03	4.10*
	τ Draconis	E.	17 58.07	— .28	+ .94	— .72	17 58.01	17 2.18	4.17*
	γ Aquilæ	E.	40 8.98	— .07	— .50	— .21	40 8.20	40 12.40	4.20
	α Aquilæ	E.	44 30.82	— .05	— .51	— .21	44 30.05	44 34.26	4.21
	ε Draconis	W.	48 33.14	— .16	+ .56	+ .53	48 34.07	48 37.98	3.91*
	τ Aquilæ	W.	19 57 51.38	— .03	— .43	+ .18	19 57 51.10	19 57 55.24	4.14
	κ Cephei	W.	20 13 6.43	— .19	+1.21	+ .93	20 13 18.28	20 13 12.62	4.34*
Sept. 5	η Serpentis	W.	18 14 38.89	— .04	—0.50	+ .18	18 14 38.61	18 14 42.84	4.23
	1 Aquilæ	W.	28 12.31	— .05	— .54	+ .18	28 11.90	28 16.28	4.38
	α Lyræ	W.	32 33.16	— .11	— .17	+ .22	32 33.10	32 37.73	4.63
	β Lyræ	W.	45 18.26	— .08	— .23	+ .21	45 18.16	45 22.77	4.61
	50 Draconis	W.	50 25.64	— .27	+ .98	+ .68	50 27.03	50 31.09	4.06*
	ζ Aquilæ	W.	18 59 29.19	— .06	— .39	+ .18	18 59 28.92	18 59 33.32	4.40
	δ Draconis	W.	19 12 27.59	— .20	+ .44	+ .45	19 12 28.38	19 12 32.97	4.59*
	τ Draconis	E.	17 58.16	— .29	+ .59	— .69	17 57.77	17 2.11	4.34*
	κ Aquilæ	E.	29 58.61	— .05	— .40	— .20	29 57.96	29 2.35	4.39
	γ Aquilæ	E.	40 8.43	— .06	— .31	— .21	40 7.85	40 12.39	4.54
	α Aquilæ	E.	44 30.26	— .06	— .32	— .20	44 29.68	44 34.25	4.57
	ε Draconis	E.	19 48 33.75	— .23	+ .43	— .59	19 48 33.36	19 48 37.92	4.56*
	π Capricorni	E.	20 19 58.19	— .03	— .46	— .21	20 19 57.49	20 19 1.98	4.49
	ε Delphini	E.	27 3.95	— .07	— .31	— .21	27 3.36	27 7.94	4.58
	α Cygni	E.	20 37 2.03	— .13	— .07	— .28	20 37 1.55	20 37 6.20	4.65
Sept. 6	ζ Aquilæ	W.	18 59 28.18	— .02	+ .04	+ .27	18 59 28.47	18 59 33.31	4.84
	δ Draconis	W.	19 12 27.30	— .01	— .05	+ .68	19 12 27.92	19 12 32.92	5.00*
	τ Draconis	W.	17 56.45	— .06	— .09	+ .90	17 57.20	17 2.04	4.84*
	κ Aquilæ	W.	29 57.17	— .02	+ .06	+ .26	29 57.47	29 2.33	4.86
	γ Aquilæ	W.	40 7.03	— .02	+ .05	+ .27	40 7.33	40 12.37	5.04
	α Aquilæ	W.	19 44 28.86	—0.02	+0.05	+0.26	19 44 29.15	19 44 34.23	+5.08

Computation of observations for clock and instrumental corrections, &c.—Continued.

GREENWICH.

Date.	Stars.	L. p.	Observed time of transit.			Corrections. Level.	Azimuth.	Collimation and aberration.	Clock-time of meridian transit.			Right ascension.			Clock-correction.
1872.			*h.*	*m.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*s.*
Sept. 6	ε Draconis	E.	19	48	34.37	−0.09	−0.37	−0.84	19	48	33.07	19	48	37.87	+ 4.80*
	τ Aquilæ	E.	19	57	50.27	− .02	+ .29	− .29	19	57	50.25	19	57	55.22	4.97
	α^2 Capricorni	E.	20	10	54.40	− .02	+ .37	− .30	20	10	54.45	20	10	59.35	4.90
	ε Delphini	E.		27	2.92	− .02	+ .27	− .29		27	2.88		27	7.93	5.05
	α Cygni	E.	20	37	1.38	− .02	+ .06	− .41	20	37	1.01	20	37	6.18	5.17
Sept. 7	η Serpentis	E.	18	14	37.43	− .04	+ .10	− .10	18	14	37.39	18	14	42.81	5.42
	1 Aquilæ	E.		28	10.82	− .03	+ .11	− .10		28	10.80		28	16.22	5.42
	α Lyræ	E.		32	32.23	− .09	+ .03	− .13		32	32.04		32	37.69	5.65
	β Lyræ	E.		45	17.36	− .07	+ .04	− .12		45	17.21		45	22.73	5.52
	50 Draconis	E.		50	26.48	− .21	− .19	− .39		50	25.69		50	30.92	5.23*
	ζ Aquilæ	E.	18	59	27.74	− .05	+ .08	− .10	18	59	27.67	18	59	33.29	5.62
	δ Draconis	E.	19	12	27.55	− .12	− .09	− .26	19	12	27.08	19	12	32.87	5.79*
	τ Draconis	W.		17	56.67	− .09	− .17	+ .25		17	56.66		17	1.97	5.31*
	κ Aquilæ	W.		29	56.74	− .01	+ .12	+ .07		29	56.93		29	2.32	5.39
	γ Aquilæ	W.		40	6.60	− .02	+ .09	+ .07		40	6.74		40	12.36	5.62
	α Aquilæ	W.		44	28.48	− .02	+ .09	+ .07		44	28.62		44	34.22	5.60
	ε Draconis	W.	19	48	32.20	− .07	− .12	+ .21	19	48	32.22	19	48	37.82	5.60*
	α^2 Capricorni	W.	20	10	53.70	+ .01	+ .12	+ .07	20	10	53.90	20	10	59.34	5.44
	ε Delphini	W.		27	2.19	+ .01	+ .09	+ .07		27	2.36		27	7.92	5.56
	α Cygni	W.	20	37	0.22	+ .01	+ .02	+ .10	20	37	0.35	20	37	6.16	5.81
Sept. 9	ζ Pegasi	W.	22	35	0.10	− .01	− .05	+ .08	22	35	0.12	22	35	7.10	6.98
	ι Cephei	W.		45	3.80	.00	+ .05	+ .19		45	4.04		45	10.94	6.90*
	α Pegasi	W.	22	58	18.50	+ .02	− .05	+ .08	22	58	18.55	22	58	25.55	7.00
	ο Cephei	W.	23	13	18.78	+ .08	+ .06	+ .20	23	13	19.12	23	13	26.24	7.12*
	θ Piscium	W.		21	23.86	+ .02	− .06	+ .08		21	23.90		21	30.96	7.06
	ω Piscium	E.	23	52	39.88	− .02	− .01	− .11	23	52	39.74	23	52	46.76	7.02
	α Andromedæ	E.	0	1	42.00	− .04	− .01	− .12	0	1	41.83	0	1	48.91	7.08
	γ Pegasi	E.		6	34.30	− .04	− .01	− .11		6	34.14		6	41.15	7.01
	α Cassiopeæ	E.		33	11.55	− .09	.00	− .19		33	11.27		33	18.34	7.07
	β Ceti	E.	0	37	5.33	−0.02	−0.02	−0.11	0	37	5.18	0	37	12.29	+ 7.11

Comparison of Greenwich clock and Coast Survey chronometer, September 10.

	Blake to Ellis.			Ellis to Blake.		
	h.	*m.*	*s.*	*h.*	*m.*	*s.*
Greenwich clock-time	22	3	15.344	22	6	7.618
Reduced to Coast Survey station			+ 0.160			+ 0.160
Correction for personal equation			+ 0.061			+ 0.061
Greenwich standard clock-correction			+48.733			+48.734
Blake's time by Greenwich observer	22	4	4.298	22	6	56.573
Blake's chronometer-time	22	3	56.655	22	6	48.922
Correction of Blake's chronometer			+ 7.643			+ 7.651

h. *m.* *s.*

Adopted at 22 6 + 7.647

Adopted chronometer-corrections from all stars south of + 60° N. declination.

BREST.

(Observer, F. Blake, jr.—Break-circuit chronometer William Bond & Sons, No. 380.)

Date.	T. (Mean of Æ's.)	Chronometer-correction at time T.	Hourly difference.	Adopted hourly rate at time T.	Chronometer-correction at $18^h\ 0^m$.
1872.	*h. m.*	*s.*	*s.*	*s.*	*s.*
July 1	17 36	+3.748		−0.021	+3.740
			−0.021		
3	16 16	2.782		0.018	2.751
			0.016		
4	17 3	2.388		0.016	2.373
			0.017		
5	16 20	1.998		0.018	1.968
			0.020		
9	16 38	+0.077		0.020	+0.050
			0.020		
11	17 40	−0.923		0.027	0.932
			0.031		
12	18 8	1.678		0.024	1.675
			0.010		
14	17 38	2.145		0.010	2.149
			0.009		
17	17 28	2.798		0.010	2.803
			−0.010		
18	18 13	3.044		0.004	3.043
			+0.001		
19	18 11	3.010		0.005	3.009
			−0.011		
20	18 11	3.268		0.008	3.267
			0.005		
21	19 27	3.404		0.009	3.391
			0.013		
22	19 1 22 33	3.705 3.761	0.016	0.016	3.689
			−0.014		
23	18 31	−4.043		−0.014	−4.036

PARIS.

Aug. 16	19 18	−1.461		+0.006	−1.469
			+0.006		
17	19 30	1.325		+0.003	1.329
			0.000		
18	19 23	1.326		−0.002	1.323
			−0.003		
19	19 36	1.391		0.004	1.385
			−0.006		
20	19 22	−1.539		−0.006	−1.531

GREENWICH.

Aug. 28	19 22	+1.730		+0.003	+1.726
			+0.003		
30	19 33	1.880		0.010	1.864
			0.014		
31	19 39	2.221		0.016	2.195
			0.021		
Sept. 3	18 44	3.718		0.018	3.705
			0.017		
4	19 10	4.126		0.016	4.107
			0.015		
5	19 23	4.497		0.018	4.472
			0.020		
6	19 53	4.989		0.022	4.948
			0.024		
7	19 23	5.550		0.025	5.515
			0.028		
9	23 46	7.041		0.027	6.885
			+0.027		
10	22 6	+7.647		+0.027	+7.536

N. B.—The hourly rate for each date at time T, is deduced from the hourly differences on either side of it, by giving them weight inversely proportional to the intervals from which they are derived.

Errors and rates of the sidereal standard clock of the Royal Observatory at Greenwich, connected with the determination of the longitude differences Greenwich — Brest and Greenwich — Paris.

Day and solar hour, 1872.		Observer.	Number of stars in each group.	Sidereal time.		Mean, clock slow.	Mean, clock slow, reduced to standard observer.	Adopted hourly losing rate.
d.	*h.*			*h.*	*m.*	*s.*	*s.*	*s.*
July 1	8	C.	9	15	7	47.24	47.24	0.002
3	9	L.	8	15	34	47.22	47.46	.010
4	8	E.	10	14	45	47.96	47.73	.010
5	7	H.	19	13	31	47.97	47.86	.008
11	12	E.	6	19	33	48.76	48.53	.006
Aug. 28	9	J. C.	6	19	35	42.44	42.43	.035
30	9	L.	6	19	34	43.55	43.79	.023
31	9	E.	6	19	45	44.53	44.30	.023
Sept. 3	9	H. C.	5	18	17	46.19	46.19	.026
4	8	L.	4	18	39	46.46	46.70	.024
5	4	J.	7	14	58	47.31	47.25	.023
5	8	J.	4	19	7	47.43	47.37*	.023
6	9	J. C.	5	19	44	51.35	51.34†	.021
7	8	E.	2	19	2	47.97	47.74	.009
7	9	P.	4	19	43	47.93	47.86‡	.009
9	12	E.	5	22	59	48.55	48.32	.014
10	8	J. C.	6	19	22	48.70	48.69	.016

The adopted values for personal equations of the Greenwich observers, applicable to "clock slow," as determined from observations made during the year 1872, Mr. Criswick being taken as standard, are:

	s.
C. — W. C.	= — 0.07
C. — E.	= — 0.23
C. — L.	= + 0.24
C. — J. C.	= — 0.01
C. — H. C.	= — 0.00
C. — P.	= — 0.07
C. — J.	= — 0.06
C. — G.	= — 0.11
C. — H.	= — 0.11

The initials W. C., E., C., L., J. C., H. C., P., J., G., and H., are those of Mr. W. H. M. Christie, Mr. William Ellis, Mr. G. S. Criswick, Mr. W. T. Lynn, Mr. J. Carpenter, Mr. H. J. Carpenter, Mr. J. P. Potts, Mr. C. A. Jenkins, Mr. G. Goldney, and Mr. W. J. Harding.

* The second result on September 5 (used in the longitude computations) has been obtained by employing the evening observations only of the observer, J. The stars used are those of the first group with the omission of three of them.

† On September 6 the clock "Hardy" was used in consequence of failure of the galvanic contact in the sidereal standard clock.

‡ Reducing E.'s result to the epoch of P.'s, and combining the two, giving P.'s result double weight, we have mean, clock slow, reduced to standard observer, at 19*h.* 43*m.*, 47*s.*822. This clock-error has been used in the longitude computations.

Computation of observations for clock and instrumental corrections of the National Observatory at Paris, France, relating to the differences of longitude, Paris — Brest and Paris — Greenwich.

OBSERVATIONS FOR INCLINATION OF AXIS OF THE GAMBEY MERIDIAN-TRANSIT (*"la lunette méridienne"*).

One division of level $= 2''.039$ F, $= \frac{2''.039}{4} \times \frac{1}{15} = 0^s.034$. The inequality of the pivots is $\mp 0^s.040 \frac{\text{Direct}}{\text{Reverse}}$. If we denote by n the difference between the sums of the west and east level-readings and by B the inclination of the axis, we will have $B = 0^s.034\, n \mp 0^s.040 \frac{\text{Direct}}{\text{Reverse}}$; and, the latitude of Paris being $48^\circ\ 50'\ 12''$, $B \sin \phi = 0^s.026\, n \mp 0^s.030 \frac{\text{Direct}}{\text{Reverse}}$.

(Observer, L. F. Folain.)

Date.	Time.		Level = n.		B sin ϕ.	
			Direct.	Reverse.	Direct.	Reverse.
	h.	m.	d.	d.		
June 27	19	20	+2.60	....	+0.038	....
	0	30	+2.70	....	+0.043	....
	1	30	....	−3.05	....	−0.049
July 1	15	10	....	−2.40	....	−0.032
	17	10	....	−1.60	....	−0.012
	17	15	+2.65	....	+0.039	....
	19	00	+3.20	....	+0.053	....
	20	10	+3.55	....	+0.062	....
2	15	30	+2.80	....	+0.043	....
3	15	00	+2.80	....	+0.043	....
	17	40	....	−1.80	....	−0.017
	19	30	+3.20	....	+0.053	....
4	16	30	....	−2.00	....	−0.022
	17	40	+3.60	....	+0.064	....
	18	43	....	−2.55	....	−0.036
	20	30	+4.30	....	+0.082	....
5	14	30	+3.60	....	+0.064	....
	17	00	....	−0.45	....	+0.018
	18	30	+4.10	....	+0.077	....
	20	08	....	−1.60	....	−0.012
6	14	40	....	−0.30	....	+0.021
	15	45	+4.00	....	+0.074	....
	18	25	....	−0.30	....	+0.021
	20	10	+5.60	....	+0.116	....
8	14	25	+3.80	....	+0.069	....
	15	55	....	−1.40	....	−0.006
9	15	10	+6.00	....	+0.126	....
	18	50	....	+0.30	....	+0.038
	19	35	+4.60	....	+0.090	....
	20	10	....	+0.40	....	+0.040
11	19	00	....	−0.20	....	+0.025
16	19	35	....	−1.40	....	−0.006
	20	00	+5.60	....	+0.116	....
19	17	00	+5.30	....	+0.108	....
	19	10	....	+0.10	....	+0.033
	21	20	+5.80	....	+0.121	....
20	17	00	+4.40	....	+0.084	....
	18	35	....	−0.20	....	+0.025
	21	40	+4.60	....	+0.090	....
21	17	40	+3.75	....	+0.068	....
	20	05	....	+0.10	....	+0.033
	21	30	+4.50	....	+0.087	....

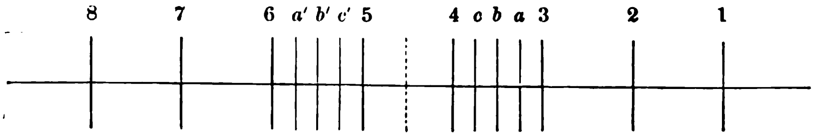
Date.	Time.		Level = n.		B sin ϕ.	
			Direct.	Reverse.	Direct.	Reverse.
	h.	m.	d.	d.		
July 22	17	20	+4.00	....	+0.074	....
	19	40	....	0.00	....	+0.030
	21	20	+5.90	....	+0.123	....
23	17	00	+6.90	....	+0.149	....
	20	45	....	+0.10	....	+0.033
24	19	08	....	0.00	....	+0.030
Aug. 12	16	45	+5.30	....	+0.108	....
16	17	00	....	+0.20	....	+0.035
	19	30	+5.30	....	+0.108	....
	20	10	....	+0.50	....	+0.043
17	17	00	....	0.00	....	+0.030
	19	35	+6.70	....	+0.144	....
	20	00	....	+0.20	....	+0.035
18	17	30	....	+0.60	....	+0.046
	18	40	+5.20	....	+0.105	....
	20	55	....	+0.20	....	+0.035
19	17	50	....	+1.00	....	+0.056
	18	40	+6.20	....	+0.131	....
	21	00	....	+0.60	....	+0.046
20	17	30	....	+1.00	....	+0.056
	18	35	+7.00	....	+0.152	....
	21	00	....	+1.20	....	+0.061
28	18	00	+5.90	....	+0.123	....
	19	17	....	−0.20	....	+0.025
	21	10	+5.50	....	+0.113	....
31	18	40	+6.65	....	+0.162	....
	20	40	....	+0.30	....	+0.038
	23	05	+5.00	....	+0.100	....
Sept. 1	18	20	+5.60	....	+0.116	....
	20	45	....	−0.65	....	+0.013
	22	05	+5.60	....	+0.116	....
7	19	30	+4.75	....	+0.094	....
	21	10	....	0.00	....	+0.030
	23	40	+5.30	....	+0.108	....
8	19	00	+4.40	....	+0.084	....
	20	00	....	−1.10	....	+0.001
	23	25	+5.40	....	+0.110	....
9	19	00	+4.60	....	+0.090	....
	20	45	....	+1.60	....	+0.072
	22	45	+5.40	....	+0.110	....
10	19	15	+6.10	....	+0.129	....
	20	40	....	+0.40	....	+0.040
	22	45	+5.60	....	+0.116	....

AZIMUTHS OF THE MERIDIAN-MARK.

The micrometer-reading of the movable thread when in the axis of collimation is determined by pointing upon the Mark in the *direct* and *reverse* portions of the instrument. If M and M¹ are the two readings, we will have $v_o = \frac{1}{2}(M + M^1)$.

Date.	Time.	Reading. Direct. M.	Reading. Reverse. M¹.	v_o.	v_o adopted.	Date.	Time.	Reading. Direct. M.	Reading. Reverse. M¹.	v_o.	v_o adopted.
	h. m.	t.	t.	t.	t.		h. m.	t.	t.	t.	t.
June 27	19 20	14.031				July 24	18 40		16.389	15.213	15.2113
	0 30	.017		15.215	15.2113		19 25	15.037			
	1 30		16.407			Aug. 12	16 45	.027			
July 1	15 10		.394				18 40	.028		15.213	15.2144
	17 00		.425	15.211					.399		
	17 15	.010				16	17 00		.404		
	19 00	.011					18 25		.405		
	20 10	.016						.028		15.215	
2	15 30	.011					19 30	.023			
3	15 00	.032					20 10		.403		
	16 20	.033		15.209		17	17 00		.401		
			.384				18 35		.397		
	17 40		.388				19 35	.036		15.217	15.2144
	19 30	.033					20 00		.398		
4	16 30		.384			18	17 30		.403		
	17 40	.049			15.2113		18 35		.402	15.215	
	19 15	.045						.026			
			.370	15.210			19 30	.027			
	20 30	.054					20 55		.403		
5	14 30	.051		15.215		19	17 50		.403		
	17 03		.378				19 30		.404		
	18 30		.380					.026		15.214	15.2144
		.058		15.214				.024			
	20 08		.360				21 00		.402		
6	14 40		.359			20	17 30		.390		
	15 45	.061		15.211			18 35		.393		
	18 25		.363					.032		15.213	
	20 00	.060					19 42	.032			
8	14 25	.048					21 00		.394		
	15 55		.378		15.2113	28	18 00		.427		
	18 00		.426	15.216				14.005		15.216	
	18 20	.011					19 09		.435		
9	15 10	.026					21 10	13.987			
	17 10		.388			31	18 40	14.008			15.2144
	18 50		.399	15.210			20 40		.421	15.215	
	19 35	.021					23 05	.007			
	20 10		.403			Sept. 1	18 20	.018			
11	19 00		.391				19 40	.021			
16	19 35		.403				20 45		.404	15.213	
	20 00	.011		15.207			22 05	.024			
19	17 00	.016				7	19 30	.025			
	19 10		.407				20 10		.404		
	20 08		.408	15.213			21 10		.403	15.215	
	21 20	.019			15.2113		23 40	.025			
20	17 00	.023				8	19 00	.024			15.2144
	17 55		.392				21 30		.402	15.214	
	19 20		.394	15.210			22 00		.405		
	21 40	.032					23 25	.025			
21	17 40	.038				9	19 00	.023			
	18 25		.386				20 00		.403		
	19 35		.386	15.212			22 45		.407	15.215	
	21 30	.038						.026			
22	17 20	.040				10	19 15	.010			
	18 15		.384				20 20		.417		
	19 40		.384	15.212					.416	15.213	
	21 20	.041					22 45	.008			15.2144
23	17 00	.031		15.211							
	17 15		.390		15.2113						

The diaphragm of the meridian-transit is composed of eight principal threads, 1, 2, 3, 4, 5, 6, 7, 8 (see figure), symmetrically disposed with respect to the axis.



In the longitude-work with Brest and Greenwich six other threads were interpolated; three (a, b, c) between the threads 3 and 4, and three (c', b', a') between the threads 5 and 6, symmetrically arranged with regard to a, b, and c. All the observations were made upon those ten threads. Generally, the ten were used; sometimes only eight, and rarely six or four. In all cases the observations were made upon symmetrical threads.

Expressed in turns and fractions of a turn of the micrometer-screw, we have the following readings:

		t.
From June 24 to July 3:	Mean of threads $(3, a, b, c, 4, 5, c', b', a', 6)$ or v_{10}	$= 15.2042$
From July 5 to September 11:	Mean of threads $(3, a, b, c, 4, 5, c', b', a', 6)$ or v_{10}	$= 15\ 2080$
From June 24 to September 11:	Mean of threads $(a, b, c, 4, 5, c', b', a')$ or v_8	$= 15.2088$
From June 24 to September 11:	Mean of threads $(b, c, 4, 5, c', b')$ or v_6	$= 15.2110$
From June 24 to September 11:	Mean of threads $(c, 4, 5, c')$ or v_4	$= 15.2187$

For the reading of the axis of collimation we have—

	t.
From June 16 to July 24:	Mean or $v_o = 15.2113$
From August 12 to September 11:	Mean or $v_o = 15.2144$

Let v_m be the position of the fictitious "mean thread," c the collimation, $k = 2^s.8707$, the value of one revolution of the micrometer-screw. We will then have for the collimation, $c = \pm\ k\ (v_o - v_m)$

+ position direct, or screw east.

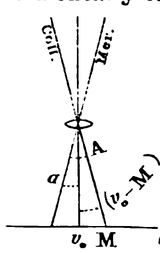
− position reverse, or screw west.

In the following table (observation of circumpolars,* page 6) t_o denotes the clock-time of the passage of the circumpolar star over the axis of collimation. Applying to this the correction $Cp + m$, (Cp = clock-correction), deduced from the observation of equatorial time-stars we get t_s, the sidereal time of the star's passage.

A denotes the right ascension, as taken from the Nautical Almanac, and to which is added a correction, as follows: For λ Ursæ Minoris, $-1^s.50$; for α, $+1^s.00$; and for δ, $-0^s.32$.

The quantity $\pm\ (A - t_s) \dfrac{+ \text{ for upper culmination}}{- \text{ for lower culmination}}$ being multiplied by cos B, where B represents the declination of the star, gives $n - x$, whence n. For Paris, $x = 0^s.0136$.

Let A be the azimuthal deviation of the meridian collimator, that is, the angle formed by the optical axis of the collimator with the plane of the meridian (+ when the collimator is to the east, − when to the west of the meridian); α the deviation of the transit-instrument, that is, the angle which the axis of collimation makes with the plane of the meridian, the instrument being pointed horizontally towards the south. The angle α does not vary in reversing the telescope.



Denoting by M the readings corresponding to the pointing upon the collimator in one or the other position, we have $A = \alpha \pm k\ (v_o - M)\ \dfrac{+\ \text{Direct}}{-\ \text{Reverse}}$, and $A \cos\varphi = \alpha \cos\varphi \pm k \cos\varphi\ (v_o - M) \dfrac{\text{D}}{\text{R}}\ \alpha \cos\varphi$ or B sin $\phi - n$ is known from what precedes.

The second term of the second member of the above equation is also known.

Knowing the different values of $A \cos\varphi$ we can, *on account of their uniformity*, deduce a mean value for $A \cos\varphi$ by combining the various results, direct and reverse. This result will be free from the effect of flexure in the axis.

* The circumpolars are observed with the movable thread.

The correction due to flexure of the instrument is applied to the inclination. This correction is given by the formula—

$$\delta\,(\mathrm{B}\sin\varphi) = \pm\,\tfrac{1}{2}\,(\mathrm{A}\cos\varphi_{\,\mathrm{reverse}} - \mathrm{A}\cos\varphi_{\,\mathrm{direct}}).$$

The values of A cos φ and of δ (B sin φ) are—

From June 27 to July 24: $\mathrm{A}\cos\varphi_{\,\mathrm{mean}} = 2^{s}.242$; $\delta\,(\mathrm{B}\sin\varphi) = \mp\, 0^{s}.33\ \frac{\mathrm{D}}{\mathrm{R}}$

From August 12 to 20: $\mathrm{A}\cos\varphi_{\,\mathrm{mean}} = 2^{s}.225$; $\delta\,(\mathrm{B}\sin\varphi) = \mp\, 0^{s}.018\ \frac{\mathrm{D}}{\mathrm{R}}$

From August 28 to Sept. 10: $\mathrm{A}\cos\varphi_{\,\mathrm{mean}} = 2^{s}.234$; $\delta\,(\mathrm{B}\sin\varphi) = \mp\, 0^{s}.027\ \frac{\mathrm{D}}{\mathrm{R}}$

The equation $a\cos\varphi = \mathrm{A}\cos\varphi \mp k\cos\varphi\,(r_o - m)\ \frac{\text{Direct}}{\text{Reverse}}$ gives, by the substitution of the above values of A cos φ (mean), a new set of values for a cos φ. The values of m and n were deduced with these values of A cos φ and those of B sin φ, corrected by the quantities given above.

OBSERVATIONS UPON THE CIRCUMPOLAR STARS α, δ, AND λ, URSÆ MINORIS.

Values of n and of the constant of the collimator.

Date.	Telescope. D. or R.	Star.	t_o			t_c	$(A-t_c)$	n.	A cos ϕ Direct.	A cos ϕ Reverse.
1872.			h.	m.	s.	s.	s.	s.	s.	s.
June 27	D.	α	1	11	59.7	42.2	+ 1.2	+0.043	+2.240	....
27	R.	α	1	11	59.9	42.4	+ 1.0	+0.038	....	+2.172
July 1	R.	λ	19	53	12.5	1.5	+ 9.4	+0.191	....	+2.052
1	D.	λ	19	53	18.6	7.6	+ 3.3	+0.076	+2.244	....
3	R.	δ	18	14	28.2	0.9	— 4.5	—0.252	....	+2.455
3	D.	δ	18	14	22.1	54.8	+ 1.6	+0.109	+2.169	....
3	D.	λ	19	53	37.4	10.1	+ 0.8	+0.029	+2.249	....
3	R.	λ	19	53	36.9	9.6	+ 1.3	+0.038	....	+2.165
4	R.	λ	19	53	27.6	9.6	+ 1.2	+0.037	....	+2.117
4	D.	λ	19	53	26.2	8.2	+ 2.6	+0.063	+2.205	....
5	D.	λ	19	53	30.7	10.1	+ 0.6	+0.025	+2.230	....
5	R.	λ	19	53	29.8	9.2	+ 1.5	+0.062	....	+2.117
6	D.	δ	18	14	14.7	56.5	— 0.6	—0.022	+2.268	....
6	R.	δ	18	14	15.1	56.9	— 1.0	—0.045	....	+2.242
6	R.	λ	19	53	29.3	11.1	— 0.5	+0.005	....	+2.192
6	D.	λ	19	53	28.5	10.3	+ 0.3	+0.020	+2.270	....
8	R.	δ	18	14	13.3	54.3	+ 1.2	+0.085	....	+2.204
9	D.	λ	19	53	29.7	9.1	+ 1.2	+0.037	+2.301	....
9	R.	λ	19	53	32.2	11.6	— 1.3	—0.010	....	+2.302
16	R.	λ	19	53	27.1	7.9	+ 2.0	+0.052	....	+2.194
16	D.	λ	19	53	26.6	7.4	+ 2.5	+0.061	+2.321	....
19	D.	{7504 B. A. C.}	21	25	03.6	59.1	+ 0.4	+0.038	+2.335	....
20	R.	λ	19	53	17.7	10.2	— 1.8	—0.020	....	+2.280
20	D.	λ	19	53	15.7	8.1	+ 0.3	+0.020	+2.297	....
21	R.	λ	19	53	12.1	4.9	+ 3.1	+0.072	....	+2.181
21	D.	λ	19	53	14.8	7.6	+ 0.4	+0.022	+2.281	....
22	R.	λ	19	53	11.5	4.4	+ 3.3	+0.076	....	+2.170
22	D.	λ	19	53	20.7	13.6	— 5.9	—0.097	+2.430	....
24	R.	δ	18	13	57.7	53.2	— 0.9	—0.039	....	+2.294
Aug. 12	D.	δ	18	14	06.6	44.1	+ 2.7	+0.174	+2.175	....
16	R.	δ	18	14	12.9	45.4	— 0.1	+0.008	....	+2.275
16	D.	λ	19	53	17.8	50.3	+ 3.8	+0.085	+2.273	....
16	R.	λ	19	53	15.7	48.2	+ 5.9	+0.125	....	+2.164
17	D.	λ	19	53	19.8	51.5	+ 1.7	+0.046	+2.323	....
17	R.	λ	19	53	18.1	49.8	+ 3.4	+0.078	....	+2.194
18	R.	δ	18	14	12.2	43.2	+ 1.3	+0.091	....	+2.199
18	D.	λ	19	53	10.4	41.4	+11.0	+0.220	+2.127	....
18	R.	λ	19	53	18.1	49.0	+ 3.4	+0.078	....	+2.203

OBSERVATIONS UPON THE CIRCUMPOLAR STARS, ETC.—Continued.

Date.	Telescope, D. or R.	Star.	t_o	t_s	$(A-t_s)$	n.	A cos φ Direct.	A cos φ Reverse.
1872.			h. m. s.	s.	s.	s.	s.	s.
Aug. 19	R.	δ	18 14 12.9	43.0	+ 1.2	+0.085	....	+2.217
19	D.	λ	19 53 15.8	45.9	+ 5.7	+0.121	+2.256	....
19	R.	λ	19 53 17.4	47.5	+ 4.1	+0.091	....	+2.199
20	D.	λ	19 53 17.8	47.1	+ 3.7	+0.083	+2.302	....
28	D.	δ	18 13 48.6	39.2	+ 1.6	+0.109	+2.298	....
28	R.	λ	19 52 50.8	41.4	+ 2.6	+0.063	....	+2.269
28	D.	λ	19 52 43.5	34.0	+10.0	+0.201	+2.230	....
31	D.	λ	19 52 46.1	32.1	+ 8.7	+0.177	+2.243	....
31	R.	λ	19 52 46.3	32.3	+ 8.5	+0.173	....	+2.145
Sept. 1	D.	λ	19 52 49.9	33.1	+ 6.7	+0.140	+2.232	....
1	R.	λ	19 52 58.0	41.2	— 1.4	—0.012	....	+2.273
7	D.	λ	19 52 53.5	31.4	+ 2.6	+0.063	+2.277	....
7	R.	λ	19 52 49.2	27.1	+ 6.9	+0.143	....	+2.133
9	D.	λ	19 52 52.5	26.7	+ 5.2	+0.111	+2.229	....
9	R.	λ	19 52 52.7	26.8	+ 5.1	+0 110	....	+2.208
10	D.	λ	19 52 53.5	26.8	+ 4.0	+0.089	+2.315	....

From June 27 to July 24: s.
Mean value of A cos φ direct .. = + 2.274
Mean value of A cos φ reverse. = 2.209
Mean...................... = + 2.242

From August 12 to 20: s.
Mean value of A cos φ direct.. = + 2.243
Mean value of A cos φ reverse. = 2.207
Mean...................... = + 2.225

From Aug. 28 to Sept. 10: s.
Mean value of A cos φ direct.. = + 2.261
Mean value of A cos φ reverse. = 2.206
Mean...................... = + 2.234

CO-EFFICIENTS EMPLOYED IN THE REDUCTION OF THE OBSERVATIONS.

Date.	Tel., D. or R.	m.	n.	c — x. 10 threads.	c — x. 8 threads.	c — x. 6 threads.	c — x. 4 threads.	Date.	Tel., D. or R.	m.	n.	c — x. 10 threads.	c — x. 8 threads.	c — x. 6 threads.	c — x. 4 threads.
1872.		s.	s.	s.	s.	s.	s.	1872.		s.	s.	s.	s.	s.	s.
July 1	R.	—0.02	+0.03	—0.03	—0.02	—0.01	+0.01	Aug. 17	R.	+0.03	+0.07	—0.03	—0.03	—0.02	0.00
1	D.	.02	.04	+ .01	.01	.01	— .03	18	R.	.03	.08	.03	.03	.02	.00
1	R.	— .02	+ .03	— .03	.02	.01	+ .01	18	D.	.05	.11	.00	.00	.00	—.03
3	D.	+ .03	— .01	+ .01	.01	.01	— .03	18	R.	.02	.07	.03	.03	.02	.00
3	R.	.04	.01	— .03	.02	.01	+ .01	19	R.	.04	.09	.03	.03	.02	.00
3	D.	.04	.00	+ .01	.01	.01	— .03	19	D.	.07	.13	.00	.00	.00	.03
4	R.	.04	.02	— .03	.02	.01	+ .01	19	R.	.03	.08	.03	.03	.02	.00
4	D.	.08	.01	.00	.01	.01	— .03	20	R.	.06	.07	.03	.03	.02	.00
4	R.	.06	.05	.03	.02	.01	+ .01	20	D.	.12	.13	.00	.00	.00	.03
5	D.	.08	— .02	.00	.01	.01	— .03	20	R.	.06	.08	.03	.03	.02	.00
5	R.	.08	+ .02	.02	.02	.01	+ .01	28	D.	+ .03	.15	.00	.00	.00	.03
5	D.	.11	— .02	.00	.01	.01	— .03	28	R.	— .04	.13	.03	.03	.02	.00
9	D.	.08	+ .09	.00	.01	.01	— .03	28	D.	— .02	.17	.00	.00	.00	.03
9	R.	.07	.06	.02	.02	.01	+ .01	31	D.	+ .05	.16	.00	.00	.00	.03
9	D.	.04	.06	.00	.01	.01	— .03	31	R.	.00	.11	.03	.03	.02	.00
19	D.	.05	.09	.00	.01	.01	— .03	31	D.	.01	.12	.00	.00	.00	.03
19	R.	.04	.09	.02	.02	.01	+ .01	Sept. 1	D.	.05	.11	.00	.00	.00	.03
19	D.	.07	.10	.00	.01	.01	— .03	1	R.	.02	.05	.03	.03	.02	.00
20	D.	.04	.05	.00	.01	.01	— .03	1	D.	.06	.10	.00	.00	.00	.03
20	R.	.06	.05	.02	.02	.01	+ .01	7	D.	.04	.08	.00	.00	.00	.03
20	D.	.07	.04	.00	.01	.01	— .03	7	R.	.04	.07	.03	.03	.02	.00
21	D.	.06	.01	.00	.01	.01	— .03	7	D.	.06	.09	.00	.00	.00	.03
21	R.	.08	.04	.02	.02	.01	+ .01	8	D.	.04	.08	.00	.00	.00	.03
21	D.	.08	.03	.00	.01	.01	— .03	8	R.	.01	.04	.03	.03	.02	.00
22	D.	.07	.01	.00	.01	.01	— .03	8	D.	.06	.09	.00	.00	.00	.03
22	R.	.09	.04	.02	.02	.01	+ .01	9	D.	.04	.08	.00	.00	.00	.03
22	D.	.11	.06	.00	.01	.01	— .03	9	R.	.07	.11	.03	.03	.02	.00
Aug. 16	R.	.02	.08	.03	.03	.02	.00	9	D.	.06	.09	.00	.00	.00	.03
16	D.	.05	.11	.00	.00	.00	.03	10	D.	.04	.14	.00	.00	.00	.03
16	R.	.03	.08	.03	.03	.02	.00	10	R.	.02	.11	— .03	— .03	— .02	.00
17	R.	.03	.06	— .03	— .03	— .02	.00	10	D.	+0.03	+0.13	0.00	0.00	0.00	— .03
17	D.	+0.11	+0.13	0.00	0.00	0.00	—0.03								

Observation with the Gambey meridian-transit for the determination of the difference of longitude between Paris and Brest.

Observations recorded upon a Morse-Digney chronograph.—Observer, L. F. Folain, assistant astronomer. $I = m + n \tan B + (c - x) \sec B$; T = time of passage corrected for I; A_c = computed AR; C_p = clock-correction; C'_p = mean clock-correction. The *west* corresponds to the *reverse* position of the instrument; the *east* to the *direct*.—Circumpolar stars are observed with the movable thread and reduced to the axis of collimation.

Stars.		Observed time of passage.			I.	T.	A_c.	C_p.	C'_p.	Concluded App. AR.		
	July 1.											
	Telescope reversed.	h.	m.	s.	s.	s.	s.	s.	s.	h.	m.	s.
ν	Coronæ Borealis	16	11	49.79	−0.04	49.75	38.84	−10.91	−10.91	16	11	38.84
ω	Herculis		19	43.15	.04	43.11	32.20	.91	.91		19	32.20
β	Herculis		24	55.67	.02	55.65	44.76	.89	.90		24	44.75
30269	Lalande		32	06.72	.03	06.69	55.88	.81	.90		31	55.79
ζ	Herculis		36	40.40	.01	40.39	29.47	.92	.90		36	29.49
i	Herculis		39	53.90	.04	53.86	42.98	.88	.89		39	42.97
ι	Ophiuchi		48	09.92	.04	09.88	58.89	.99	.89		47	58.99
κ	Ophiuchi	16	51	49.31	−0.04	49.27	38.34	−10.93	−10.89	16	51	38.38
	Telescope direct.											
79	Herculis	17	32	27.50	+0.01	27.51	16.66	−10.85	−11.01	17	32	16.50
β	Ophiuchi		37	21.75	−0.01	21.74	10.80	−10.94	.01		37	10.73
μ	Herculis	17	41	39.78	+0.01	39.79	28.86	−10.93	.01	17	41	28.78
A	Herculis	18	07	18.20	.02	18.22	07.13	−11.09	.00	18	07	07.22
6203	B. A. C		11	53.03	.03	53.06	41.96	−11.10	.00		11	42.06
106	Herculis		15	05.93	+0.01	05.94	51.93	−11.01	.00		14	54.94
34128	Lalande		21	56.58	−0.01	56.57	45.73	−10.84	−11.00		21	45.57
34319	Lalande		26	30.26	.00	30.26	19.20	−11.06	−10.99		26	19.27
34475	Lalande		29	17.35	.00	17.35	06.29	−11.06	.99		29	06.36
	Vega		32	49.42	.00	49.42	38.32	−11.10	.99		32	38.43
35005	Lalande		43	18.71	.01	18.70	07.93	−10.77	.98		43	07.72
β	Lyræ		45	34.27	−0.01	34.26	23.20	−11.06	.98		45	23.28
δ	Lyræ	18	49	28.35	+0.02	28.37	17.32	−11.05	−10.98	18	49	17.39
	Telescope reversed.											
ω	Aquilæ	19	12	01.22	−0.04	01.18	50.34	−10.84	−10.83	19	11	50.35
6624	B. A. C		14	54.27	.02	54.25	43.39	.86	.83		14	43.42
δ	Aquilæ		19	15.40	.05	15.35	04.52	.83	.83		19	04.52
4	Cygni		21	45.34	.04	45.30	34.52	.78	.83		21	34.47
β^1	Cygni		25	46.29	.04	46.25	35.43	.82	.83		25	35.42
9	Cygni		29	58.49	.04	58.45	47.67	.78	.83		29	47.62
6728	B. A. C		32	40.95	.01	40.94	30.11	.83	.83		32	30.11
γ	Aquilæ		40	23.22	−0.05	23.17	12.26	−10.91	−10.83	19	40	12.34
λ	Ursæ Minoris	19	53	12.50	+0.80	13.30	10.90	......	......	......		
	Telescope direct.											
λ	Ursæ Minoris	19	53	18.60	+2.00	20.60	10.90	......	......	......		
	July 3.											
	Telescope direct.											
μ	Bootis	15	20	08.25	+0.03	08.28	40.95	−27.33	−27.49	15	19	40.79
β	Coronæ Borealis		23	02.04	.03	02.07	34.69	.38	.49		22	32.58
5113	B. A. C		25	48.00	.03	48.03	20.41	.62	.48		25	20.55
α	Coronæ Borealis		29	45.12	.04	45.16	17.66	.50	.48		29	17.68
α	Serpentis		38	26.84	.04	26.88	59.36	.52	.47		37	59.41
ν	Serpentis	15	41	49.67	+0.04	49.71	22.21	−27.50	−27.46	15	41	22.25
	Telescope reversed.											
30269	Lalande	16	32	23.09	+0.01	23.10	55.88	−27.22	−27.44	16	31	55.66
ζ	Herculis		36	56.73	.00	56.73	29.46	.27	.44		36	29.29
i	Herculis		40	10.37	+0.02	10.39	42.98	.41	.43		39	42.96
5644	B. A. C		43	43.40	−0.01	43.39	15.96	.43	.42		43	15.97
ι	Ophiuchi		48	26.32	+0.01	26.33	58.89	.44	.42		47	58.91
κ	Ophiuchi		52	05.81	.01	05.82	38.34	.48	.41		51	38.41
ε	Herculis		55	52.85	.00	52.85	25.37	.48	.41		55	25.44
60	Herculis	16	59	55.81	+0.01	55.82	28.28	−27.54	−27.41	16	59	28.41

Observations with the Gambey meridian-transit, &c.—Continued.

Stars.		Observed time of passage.			I.	T.	A_c.	C_p.	C'_p.	Concluded App. AR.		
	JULY 3.											
	Telescope reversed—Continued.	*h.*	*m.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*
5788	B. A. C	17	03	59.04	−0.01	59.03	31.75	−27.28	−27.41	17	03	31.62
α	Herculis		09	17.84	+0.01	17.85	50.47	.38	.41		08	50.44
μ	Herculis		13	05.23	.00	05.23	37.75	.48	.40		12	37.83
70	Herculis		16	07.17	.00	07.17	39.77	.40	.40		15	39.77
73	Herculis		19	14.53	.00	14.53	47.11	.42	.39		18	47.14
31844	Lalande		22	39.68	.00	39.68	12.25	.43	.39		22	12.29
λ	Herculis		26	03.32	.00	03.32	31.83	.49	.38		25	35.94
α	Ophiuchi	17	29	28.80	+0.01	28.81	01.42	−27.39	−27.38	17	29	01.43
δ	Ursæ Minoris	18	14	28.2	−0.40	27.8	56.4	....	....	....		
	Telescope direct.											
δ	Ursæ Minoris	18	14	22.1	−0.2	21.9	56.4	....	....	....		
34319	Lalande		26	46.34	+0.05	46.39	19.22	−27.17	−27.29	18	26	19.10
34475	Lalande		29	33.60	.05	33.65	06.30	.35	.29		29	06.36
	Vega		33	05.55	.05	05.60	38.33	.27	.28		32	38.32
6365	B. A. C		36	21.16	.05	21.21	53.89	.32	.28		35	53.93
110	Herculis		40	38.37	.05	38.42	11.12	.30	.27		40	11 15
35005	Lalande		43	35.03	.05	35.08	07.95	.13	.27		43	07.81
β	Lyræ		45	50.36	.05	50.41	23.22	.19	.26		45	23.15
γ	Lyræ	18	59	38.52	.05	38.57	11.30	.27	.25		54	11.32
ζ	Aquilæ	19	00	00.81	+0.03	00.84	33.44	−27.40	−27.25	18	59	33.59
λ	Ursæ Minoris	19	53	37.4	−0.7	36.7	10.9	....	....	....		
	Telescope reversed.											
λ	Ursæ Minoris	19	53	36.9	−1.2	35.7	10.9	....	....	....		
	JULY 4.											
	Telescope reversed.											
70	Herculis	17	15	57.92	.00	57.92	39.77	−18.15	−18.00	17	15	39.92
73	Herculis		19	05.09	.00	05.09	47.11	−17.98	.00		18	47.09
31844	Lalande		22	30.14	+0.01	30.15	12.25	.90	.00		22	12.15
λ	Herculis		25	53.80	.00	53.80	35.83	.97	.00		25	35.80
α	Ophiuchi		29	19.40	.01	19.41	01.42	.99	.00		29	01.41
79	Herculis		32	34.62	.00	34.62	16.66	−17.96	.00		32	16.62
β	Ophiuchi	17	37	28.83	+0.02	28.85	10.80	−18.05	−18.00	17	37	10.85
	Telescope direct.											
106	Herculis	18	15	12.75	+0.08	12.83	54.94	−17.89	−17.98	18	14	54.85
109	Herculis		18	34.34	.08	34.42	16.46	.96	.98		18	16.44
34128	Lalande		22	03.36	.08	03.44	45.74	−17.70	.98		21	45.46
34319	Lalande		26	37.22	.07	37.29	19.22	−18.07	.98		26	19.31
34475	Lalande		29	24.40	.08	24.48	06.30	−18.18	.98		29	06.50
	Vega		32	56.25	.07	56.22	38.33	−17.99	.98		32	38.34
6365	B. A. C		36	11.83	.06	11.89	53.89	−18.00	.98		35	53.91
110	Herculis		40	29.04	.08	29.12	11.12	−18.00	.98		40	11.14
35005	Lalande		43	25.76	.07	25.83	07.95	−17.88	.98		43	07.85
β	Lyræ		45	41.09	.07	41.16	23.22	−17.94	.98		45	23.18
δ	Lyræ		49	35.30	.07	35.37	17.34	−18.03	.98		49	17.39
γ	Lyræ		54	29.29	.06	29.35	11.31	.04	.98		54	11.37
ζ	Aquilæ	18	59	51.42	.08	51.50	33.45	−18.05	.97	18	59	33.53
ι	Lyræ	19	03	03.93	+0.07	04.00	46.06	−17.94	−17.97	19	02	46.03
	Telescope reversed.											
6624	B. A. C	19	15	01.40	−0.01	01.39	43.41	−17.98	−17.98	19	14	43.41
δ	Aquilæ		19	22.55	+0.03	22.58	04.55	−18.03	.98		19	04.60
4	Cygni		21	52.62	−0.01	52.61	34.55	.06	.98		21	34.63
β^1	Cygni		25	53.48	.00	53.48	35.46	−18.02	.98		25	35.50
9	Cygni		30	05.61	+0.02	05.63	47.71	−17.92	.98		29	47.65
6728	B. A. C		32	48.07	.00	48.07	30.14	.93	.98		32	30.09
14	Cygni		35	36.49	−0.02	36.67	18.55	−17.92	.98		35	18.49
γ	Aquilæ		40	30.29	+0.02	30.31	12.30	−18.01	−17.98	19	40	12.33
λ	Ursæ Minoris	19	53	27.6	−0.33	24.3	10.8	....	....	....		

Observations with the Gambey meridian-transit, &c.—Continued.

Stars.	Observed time of passage.			I.	T.	A_c.	C_p.	C'_p.	Concluded App. AR.		
JULY 4.											
Telescope direct.	*h.*	*m.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*
Ursæ Minoris	19	53	26.2	−1.1	25.1	10.8	....	....	....		
JULY 5.											
Telescope direct.											
α Serpentis	15	38	19.90	+0.08	19.98	59.35	−20.63	−20.67	15	37	59.31
υ Serpentis		41	42.78	.07	42.85	22.19	.66	.67		41	22.18
δ Coronæ Borealis		44	35.74	.07	35.81	15.23	.58	.67		44	15.14
28950 Lalande		48	05.63	.07	05.70	44.98	.72	.67		47	45.03
λ Coronæ Borealis		51	30.54	.06	30.60	09.84	.76	.67		51	09.93
5310 B. A. C		54	36.34	.06	36.40	15.73	.67	.67		54	15.73
29273 Lalande	15	58	27.02	+0.06	27.08	06.44	−20.64	−20.67	15	58	06.41
Telescope reversed.											
ζ Herculis	16	36	50.21	+0.07	50.28	29.45	−20.83	−20.49	16	36	29.79
μ Herculis	17	12	58.20	.07	58.27	37.75	.52	.50	17	12	37.77
70 Herculis		16	00.18	.07	00.25	39.77	.48	.50		15	39.75
73 Herculis		19	07.50	.07	07.57	47.11	.46	.50		18	47.07
31844 Lalande		22	32.65	.07	32.72	12.25	.47	.50		22	12.22
λ Herculis		25	56.24	.07	56.31	35.83	.48	.50		25	35.81
α Ophiuchi		29	21.89	.06	21.95	01.42	.53	.50		29	01.45
79 Herculis		32	36.98	.07	37.05	16.67	.38	.50		32	16.55
β Ophiuchi		37	31.32	.06	31.38	10.81	.57	.50		37	10.88
μ Herculis		41	49.33	.07	49.40	28.87	.53	.50		41	28.90
32628 Lalande		45	08.78	.06	08.84	48.39	.45	.50		44	48.34
6062 B. A. C		48	17.26	.07	17.33	56.90	.43	.51		47	56.82
θ Herculis		52	14.25	.07	14.32	53.82	.50	.51		51	53.81
96 Herculis	17	57	17.03	.07	17.10	56.74	.36	.51	17	56	56.59
98 Herculis	18	01	00.87	+0.07	00.94	40.39	−20.55	−20.51	18	00	40.43
Telescope direct.											
35005 Lalande	18	43	28.52	+0.11	28.63	07.96	−20.67	−20.72	18	43	07.91
β Lyræ		45	43.89	.10	43.99	23.23	.76	.72		45	23.27
δ[1] Lyræ	18	49	38.06	.10	38.16	17.35	.81	.72	18	49	17.44
ι Lyræ	19	03	06.69	.10	06.79	46.07	.72	.72	19	02	46.07
19 Lyræ		07	14.07	.10	14.17	53.42	.75	.72		06	53.45
ω Aquilæ		12	10.94	.11	11.05	50.39	.66	.72		11	50.33
6624 B. A. C		15	04.00	+0.09	04.09	43.42	−20.67	−20.72	19	14	43.37
λ Ursæ Minoris	19	53	30.7	−1.7	29.0	10.7	....	....	....		
Telescope reversed.											
λ Ursæ Minoris	19	53	29.7	−3.3	26.4	10.7	....	....	....		
JULY 9.											
Telescope direct.											
ζ Herculis	16	36	50.12	+0.14	50.26	29.43	−20.83	−20.84	16	36	29.42
i Herculis		40	03.74	.09	03.83	42.97	.86	.84		39	42.99
5644 B. A. C		43	36.60	.16	36.76	15.92	.84	.83		43	15.93
ι Ophiuchi		48	19.56	.10	19.66	58.88	.78	.83		47	58.83
κ Ophiuchi		51	58.97	.10	59.07	38.33	.74	.83		51	38.24
ε Herculis		55	46.09	.13	46.22	25.35	.87	.82		55	25.40
60 Herculis	16	59	49.06	+0.10	49.16	28.27	−20.89	−20.82	16	59	28.34
Telescope reversed.											
73 Herculis	17	19	07.81	+0.07	07.88	47.11	−20.77	−20.95	17	18	46.93
31844 Lalande		22	32.93	.09	33.02	12.24	.78	.94		22	12.08
λ Herculis		25	56.65	.08	56.73	35.83	.90	.93		25	35.80
α Ophiuchi		29	22.30	.06	22.36	01.43	.93	.92		29	01.44
θ Herculis	17	52	14.49	.09	14.58	53.82	.76	.91	17	51	53.67
A Herculis	18	07	28.05	.08	28.13	07.16	.97	.90	18	07	07.23
6203 B. A. C		12	02.83	.10	02.93	41.97	.96	.90		11	42.03
106 Herculis		15	15.71	.07	15.78	54.97	−20.81	.90		14	54.88
109 Herculis	18	18	37.54	+0.07	37.61	16.49	−21.12	−20.89	18	18	16.72

Observations with the Gambey meridian-transit, &c—Continued.

Stars.		Observed time of passage.			I.	T.	A_c.	C_p.	C'_p.	Concluded App. AR.		
	JULY 9.											
	Telescope reversed—Continued.	*h.*	*m.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*
34128	Lalande	18	22	06.45	+0.06	06.51	45.77	−20.74	−20.88	18	21	45.63
110	Herculis		40	32.12	.07	32.19	11.16	21.03	.87		40	11.32
35005	Lalande		43	28.87	.05	28.92	08.00	20.92	.86		43	08.06
γ	Lyræ	18	54	32.26	+0.08	32.34	11.35	−20.99	−20.85	18	54	11.49
	Telescope direct.											
ζ	Aquilæ	18	59	54.04	+0.06	54.10	33.50	−20.60	−20.70	18	59	33.40
ι	Lyræ	19	03	06.69	.08	06.77	46.10	.67	.70	19	02	46.07
19	Lyræ		07	14.17	.08	14.25	53.46	.79	.69		06	53.56
ω	Aquilæ		12	11.21	.05	11.26	50.43	.83	.69		11	50.57
6624	Lyræ		15	03.84	.09	03.93	43.46	.47	.69		14	43.24
δ	Aquilæ		19	25.14	.04	25.18	04.62	20.56	.68		19	04.50
4	Cygni		21	55.30	.08	55.38	34.61	20.77	.68		21	34.70
β¹	Cygni		25	56.30	+0.07	56.37	35.52	−20.85	−20.68	19	25	35.69
λ	Ursæ Minoris	19	53	29.7	+2.5	32.2	10.3	....	....	...	...	......
	Telescope reversed.											
λ	Ursæ Minoris	19	53	32.2	+3.6	35.8	10.3	....	....	...	...	......
	JULY 19.											
	Telescope direct.											
70	Herculis	17	15	44.25	+0.08	44.33	39.71	−04.62	−4.70	17	15	39.63
73	Herculis	17	18	51 65	.09	51.74	47.07	.67	.70	17	18	47.04
6365	B. A. C	18	35	58.67	.12	58.79	53.92	.87	.69	18	35	54.10
110	Herculis		40	15.78	.08	15.86	11.19	.67	.69		40	11.17
35005	Lalande		43	12.55	.09	12.60	08.06	.54	.69		43	07.91
γ	Lyræ		54	16.06	.11	16.17	11.37	.80	.68		54	11.49
ζ	Aquilæ	18	59	38.15	+0.07	38.22	33.56	−4.66	−4.68	18	59	33.54
	Telescope reversed.											
6624	B. A. C	19	14	48.47	+0.09	48.56	43.50	−5.06	−4.97	19	14	43.59
δ	Aquilæ		19	09.68	.02	09.70	04.71	−4.99	.97		19	04.73
4	Cygni		21	39.44	.12	39.56	34.66	.90	.97		21	34.59
β¹	Cygni		25	40.50	.06	40.56	35.59	.97	.97		25	35.59
9	Cygni		29	52.68	.07	52.75	47.84	.91	.96		29	47.79
6728	B. A. C		32	35.12	.10	35.22	30.24	.98	.96		32	30.26
14	Cygni		35	23.26	.10	23.36	18.66	−4.70	.96		35	18.40
γ	Aquilæ		40	17.45	.04	17.49	12.47	−5.02	.96		40	12.53
α	Aquilæ		44	39.28	.03	39.31	34.32	−4.99	.96		44	31.35
β	Aquilæ		49	08.49	.03	08.52	03.57	.95	.95		49	03.57
6857	B. A. C		52	54.15	.09	54.24	49.27	−4.97	.95		52	49.29
6882	B. A. C	19	56	26.30	.06	26.36	21.34	−5.02	.95	19	56	21.41
17	Vulpeculæ	20	01	30.35	+0.06	30.41	25.42	−4.99	−4.95	20	01	25.46
	Telescope direct.											
32	Vulpeculæ	20	49	12.74	+0.12	12.86	08.27	−4.59	−4.65	20	49	08.21
ν	Cygni		52	30.64	.15	30.79	26.16	.63	.65		52	26.14
7313	B. A. C	20	57	32.97	.15	33.12	28.48	.64	.65	20	57	28.47
61	Cygni	21	01	16.38	.15	16.53	11.81	.72	.65	21	01	11.88
γ	Equulei		04	13.52	.09	13.61	08.93	.68	.65		04	08.96
ζ	Cygni		07	35.84	.13	35.97	31.28	.69	.65		07	31.32
σ	Cygni		12	29.78	+0.15	29.93	25.32	−4.61	−4.65	21	12	25.28
7504	B. A. C	21	25	03.6	+1.5	05.1	59.5	....	....	...	...	......
	JULY 20.											
	Telescope direct.											
31844	Lalande	17	22	19.49	+0.08	19.57	12.16	−7.41	−7.47	17	22	12.10
λ	Herculis		25	43.13	.06	43.19	35.78	.41	.47		25	35.72
α	Ophiuchi		29	08.90	.05	08.95	01.40	.55	.46		29	01.49
79	Herculis		32	23.98	.06	24.04	16.62	.42	.46		32	16.58
β	Ophiuchi	17	37	18.34	+0.04	18.38	10.81	−7.57	−7.46	17	37	10.92

Observations with the Gambey meridian-transit, &c.—Continued.

Stars.		Observed time of passage.			I.	T.	A_c.	C_p.	C'_p.	Concluded App. AR.		
	JULY 20.											
	Telescope direct—Continued.	h.	m.	s.	s.	s.	s.	s.	s.	h.	m.	s.
μ	Herculis	17	41	36.21	+0.07	36.28	28.82	−7.46	−7.46	17	41	28.82
32628	Lalande		44	55.86	.05	55.91	48.39	.52	.45		44	48.46
6062	B. A. C	17	48	04.13	+0.08	04.21	56.83	−7.38	−7.45	17	47	56.76
	Telescope reversed.											
A	Herculis	18	07	14.73	+0.07	14.80	07.14	−7.66	−7.73	18	07	07.07
6203	B. A. C		11	49.50	.08	49.58	41.92	.66	.73		11	41.85
106	Herculis		15	02.60	.06	02.66	54.97	.69	.73		14	54.93
109	Herculis		18	24.33	.06	24.39	16.50	.89	.72		18	16.67
34128	Lalande		21	53.38	.04	53.42	45.79	.63	.72		21	45.70
34319	Lalande		26	27.04	.05	27.09	19.28	.81	.72		26	19.37
34475	Lalande		29	14.12	.08	14.20	06.30	.90	.71		29	06.49
35005	Lalande		43	15.60	.04	15.64	08.06	.58	.71		43	07.93
β	Lyræ		45	30.89	.07	30.96	23.27	.69	.71		45	23.25
δ¹	Lyræ		49	25.07	.07	25.14	17.38	.76	.70		49	17.44
γ	Lyræ		54	18.98	.07	19.05	11.37	.68	.70		54	11.35
ζ	Aquilæ	18	59	41.07	.05	41.12	33.56	.56	.70	18	59	33.42
ι	Lyræ	19	02	53.74	.07	53.81	46.13	.68	.69	19	02	46.12
19	Lyræ		07	01.12	.07	01.19	53.51	.68	.69		06	53.50
ω	Aquilæ		11	58.20	+0.05	58.25	50.50	−7.75	−7.69	19	11	50.56
λ	Ursæ Minoris	19	53	17.7	+2.0	19.7	08.4	....	....	....		
	Telescope direct.											
λ	Ursæ Minoris	19	53	15.7	+1.5	17.2	08.4	....	....	....		
γ	Equulei	21	04	16.39	+0.08	16.47	08.94	−7.53	−7.35	21	04	09.12
ζ	Cygni		07	38.52	.09	38.61	31.29	.32	.35		07	31.26
σ	Cygni		12	32.64	.10	32.74	25.33	.41	.34		12	25.40
1	Pegasi		16	19.23	.08	19.31	11.90	.41	.34		16	11.97
7444	B. A. C		19	02.20	.09	02.29	54.98	.31	.34		18	54.95
70	Cygni		22	17.28	.10	17.38	10.24	.14	.34		22	10.04
β	Aquarii		24	58.35	.07	58.42	51.17	.25	.33		24	51.09
ρ	Cygni	21	29	19.36	+0.11	19.47	12.16	−7.31	−7.33	21	29	12.14
	JULY 21.											
	Telescope direct.											
θ	Herculis	17	52	01.03	+0.06	01.09	53.75	−7.34	−7.31	17	51	53.78
96	Herculis	17	57	03.91	.06	03.97	56.73	.24	.31	17	56	56.66
98	Herculis	18	00	47.64	.05	47.69	40.39	.30	.31	18	00	40.38
34422	Lalande		03	46.71	.06	46.77	39.44	.33	.31		03	39.46
A	Herculis		07	14.30	.07	14.37	07.13	.24	.31		07	07.06
6203	B. A. C		11	49.16	.07	49.23	41.91	.32	.31		11	41.92
106	Herculis		15	02.16	.06	02.22	54.96	.26	.31		14	54.91
109	Herculis	18	18	23.85	+0.06	23.91	16.49	−7.42	−7.31	18	18	16.60
	Telescope reversed.											
	Vega	18	32	45.64	+0.09	45.73	38.33	−7.40	−7.26	18	32	38.47
6365	B. A. C		36	01.13	.09	01.22	53.91	.31	.26		35	53.96
110	Herculis		40	18.37	.07	18.44	11.19	.25	.26		40	11.18
35005	Lalande		43	15.12	.06	15.18	08.06	.12	.26		43	07.92
β	Lyræ		45	30.50	.08	30.58	23.26	.32	.26		45	23.32
δ¹	Lyræ		49	24.50	.08	24.58	17.37	.21	.26		49	17.32
γ	Lyræ		54	18.51	.08	18.59	11.37	.22	.26		54	11.33
ζ	Aquilæ	18	59	40.80	.07	40.87	33.56	.31	.26	18	59	33.61
19	Lyræ	19	07	00.61	.08	00.69	53.51	.18	.26	19	06	53.43
ω	Aquilæ		11	57.67	.07	57.74	50.51	.23	.26		11	50.48
6624	Lyræ		14	50.65	.09	50.74	43.50	.24	.26		14	43.48
δ	Aquilæ		19	11.99	.06	12.05	04.72	.33	.26		19	04.79
4	Cygni		21	41.83	.09	41.92	34.66	.26	.26		21	34.66
β¹	Cygni		25	42.87	.08	42.95	35.60	.35	.26		25	35.69
9	Cygni		29	55.00	+0.09	55.08	47.84	−7.24	−7.26	19	29	47.82
λ	Ursæ Minoris	19	53	12.1	+1.5	13.6	08.0	....	....	....		

Observations with the Gambey meridian-transit, &c.—Continued.

	Stars.	Observed time of passage.			I.	T.	A_c.	C_p.	C'_p.	Concluded App. AR.		
	JULY 21.											
	Telescope direct.	*h.*	*m.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*
λ	Ursæ Minoris	19	53	14.8	+1.0	15.8	08.0	....	....	....		
32	Vulpeculæ	20	49	15.48	+0.09	15.57	08.29	−7.28	−7.33	20	49	08.24
ν	Cygni		52	33.49	.11	33.60	26.18	.42	.33		52	26.27
7313	B. A. C	20	57	35.70	.10	35.80	28.50	.30	.33	20	57	28.47
61	Cygni	21	01	19.14	.10	19.24	11.84	.40	.33	21	01	11.91
γ	Equulei		04	16.21	.08	16.29	08.96	.33	.33		04	08.96
ζ	Cygni		07	38.49	.10	38.59	31.31	.28	.33		07	31.26
σ	Cygni		12	32.57	.10	32.67	25.35	.32	.33		12	25.34
ι	Pegasi		16	19.18	.09	19.27	11.92	.35	.33		16	11.94
β	Aquarii	21	24	58.38	+0.07	58.45	51.18	−7.27	−7.33	21	24	51.12
	JULY 22.											
	Telescope direct.											
θ	Herculis	17	52	00.97	+0.07	01.04	53.74	−7.30	−7.20	17	51	53.84
96	Herculis	17	57	03.79	.08	03.87	56.72	.19	.20	17	56	56.67
98	Herculis	18	00	47.51	.08	47.59	40.38	.21	.20	18	00	40.39
33422	Lalande		03	46.52	.07	46.59	39.43	.16	.20		03	39.39
A	Herculis	18	07	14.24	+0.08	14.32	07.12	−7.20	−7.20	18	07	07.12
	Telescope reversed.											
34128	Lalande	18	21	52.69	+0.07	52.76	45.78	−6.98	−7.12	18	21	45.64
6365	B. A. C		36	01.00	.11	01.11	53.90	−7.21	.12		35	53.99
110	Herculis		40	18.27	.08	18.35	11.18	.17	.12		40	1[illegible].23
35005	Lalande		43	15.01	.07	15.08	08.06	.02	.12		43	07.96
β	Lyræ		45	30.33	.09	30.42	23.26	.16	.13		45	23.29
δ^1	Lyræ		49	24.46	.09	24.55	17.37	.18	.13		49	17.42
γ	Lyræ		54	18.43	.09	18.52	11.36	.16	.13		54	11.39
ζ	Aquilæ	18	59	40.69	.08	40.77	33.56	.21	.13	18	59	33.64
ω	Aquilæ	19	11	57.67	.08	57.75	50.51	.24	.13	19	11	50.62
6624	B. A. C		14	50.47	.11	50.58	43.49	.09	.13		14	43.49
δ	Aquilæ		19	11.82	.07	11.89	04.72	.17	.14		19	04.79
4	Cygni		21	41.65	.10	41.75	34.66	.09	.14		21	34.61
β^1	Cygni		25	42.64	.09	42.73	35.60	.13	.14		25	35.59
ρ	Cygni		29	54.82	+0.09	54.91	47.89	−7.06	−7.14	19	29	47.77
λ	Ursæ Minoris	19	53	11.9	+1.5	13.0	07.7	....	....	....		
	Telescope direct.											
λ	Ursæ Minoris	19	53	20.7	+2.6	23.3	07.7	....	....	....		
7313	B. A. C	20	57	35.53	+0.16	35.69	28.91	−7.18	−7.23	20	57	28.46
61	Cygni	21	01	19.03	.16	19.19	11.89	.34	.23	21	01	11.96
γ	Equulei		04	16.09	.12	16.21	08.97	.24	.23		04	08.98
ζ	Cygni		07	38.47	.14	38.61	31.32	.29	.24		07	31.38
σ	Cygni		12	32.48	.16	32.64	25.36	.28	.24		12	25.40
ι	Pegasi		16	19.07	.13	19.20	11.93	.27	.24		16	11.96
β	Aquarii	21	24	58.22	.10	58.32	51.20	.12	.21	21	24	51.08
γ	Aquarii	22	19	11.57	.11	11.68	04.55	.13	.25	22	19	04.43
η	Aquarii		28	55.67	.11	55.78	48.49	.29	.25		28	48.53
ζ	Pegasi		35	13.52	.12	13.64	06.41	−7.27	.25		39	06.39
☾	2d limb	22	41	08.30	+0.09	08.39	....	....	−7.25	22	41	01.14

LONGITUDE PARIS AND BREST.

Table of clock-corrections and hourly rates at Paris.

Date.	Sidereal time.		Correction.	Hourly rate.*
1872.	*h.*	*m.*	*s.*	*s.*
July 1	18	07	—10.93	+0.024
3	17	13	27.38	.066
4	18	33	17.98	+0.010
5	17	27	20.59	—0.016
9	18	05	20.82	+0.059
19	19	38	4.81	.015
20	19	05	7.55	+0.032
21	19	22	7.29	—0.007
July 22	19	49	— 7.18	—0.011

* The hourly rate is derived from the observations made at the beginning and close of each night's work, the instrument being in the same position.

Observations with the Gambey meridian-transit and the Morse-Digney chronograph for the determination of the difference of personal equation between Messrs. Blake and Folain.

Stars.		Observed time of passage.			I.	T.	A_c.	C_p.	C'_p.	Concluded App. AR.		
	AUGUST 16, 1872.											
	Telescope reversed.	*h.*	*m.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*
32628	Lalande	17	45	15.73	+0.01	15.74	48.17	—27.57	—27.62	17	44	48.12
	Herculis		52	21.03	.04	21.07	53.40	.67	.62		51	53.45
96	Herculis	17	57	24.06	.02	24.08	56.50	.58	.63	17	56	56.45
98	Herculis	18	01	07.67	.02	07.69	40.16	.53	.63	18	00	40.06
33422	Lalande		04	06.75	.05	06.80	39.05	.79	.63		03	39.17
A	Herculis		07	34.53	+0.03	34.96	06.86	—27.70	—27.63	18	07	06.93
δ	Ursæ Minoris	18	14	12.9	+1.2	14.1	45.3	....	....			....
	Telescope direct.											
	Vega	18	33	05.38	+0.14	05.52	38.06	—27.46	—27.49	18	32	38.03
6365	B. A. C		36	21.20	.14	21.34	53.65	.69	.49		35	53.85
110	Herculis		40	38.43	.09	38.52	11.09	.47	.49		40	11.03
β	Lyræ		45	50.40	.12	50.52	23.06	.46	.50		45	23.02
δ¹	Lyræ		49	44.44	.13	44.57	17.16	.41	.50		49	17.07
γ	Lyræ	18	54	38.49	.12	38.61	11.20	.41	.51		54	11.10
ζ	Aquilæ	19	00	00.93	.08	01.01	33.48	.53	.51	18	59	33.50
ω	Aquilæ		12	17.97	.07	18.04	50.46	.58	.52	19	11	50.52
δ	Aquilæ		19	32.18	.06	32.24	04.72	.52	.52		19	04.72
β	Cygni		26	02.95	.11	03.06	35.53	.53	.53		25	35.53
γ	Aquilæ		40	40.00	+0.07	40.07	12.52	—27.55	—27.54	19	40	12.53
λ	Ursæ Minoris	19	53	17.8	+5.2	23.0	54.1	....	....			....
	Telescope reversed.											
λ	Ursæ Minoris	19	53	15.7	+3.6	19.3	54.1	....	....			....
o	Cygni	20	10	06.03	+0.08	06.11	38.25	—27.86	—27.71	20	09	38.40
6996	B. A. C		14	04.84	.06	04.90	37.08	.82	.71		13	37.19
γ	Cygni		18	08.08	.06	08.14	40.22	.92	.72		17	40.42
ε	Delphini		27	35.68	.02	35.70	07.98	.72	.72		27	07.98
α	Delphini		34	11.30	.02	11.32	43.73	.59	.72		33	43.60
α	Cygni		37	33.89	.07	33.96	06.30	.66	.73		37	06.23
ε	Cygni	20	41	31.54	+0.09	31.59	04.12	—27.47	—27.73	20	41	03.86
	AUGUST 17, 1872.											
	Telescope reversed.											
6203	B. A. C	18	12	00.83	+0.04	00.87	41.53	—28.34	—28.18	18	11	41.69
106	Herculis		15	22.99	.02	23.01	54.76	.25	.18		14	54.83
109	Herculis		18	44.55	.02	44.57	16.29	.28	.18		18	16.39
34128	Lalande	18	22	13.73	+0.01	13.74	45.65	—28.09	—28.18	18	21	45.56

Observations with the Gambey meridian-transit and the Morse-Digney chronograph, &c.—Continued.

Stars.	Observed time of passage.			I.	T.	A_c.	C_p.	C'_p.	Concluded App. AR.		
AUGUST 17, 1872.											
Telescope reversed—Continued.	*h.*	*m.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*
34319 Lalande	18	26	47.37	+0.01	47.38	19.13	−28.25	−28.18	18	26	19.20
34475 Lalande		29	33.80	.04	33.84	05.98	−27.86	.18		29	05.66
Vega	18	33	06.22	+0.04	06.26	38.05	−28.21	−28.18	18	32	38.08
Telescope direct.											
β Lyræ	18	45	51.21	+0.19	51.40	23.05	−28.35	−28.42	18	45	22.98
δ¹ Lyræ		49	45.37	.21	45.58	17.14	.44	.42		49	17.16
γ Lyræ	18	54	39.46	.19	39.65	11.19	.46	.42		54	11.23
ζ Aquilæ	19	00	01.79	.14	01.93	33.48	.45	.42	18	59	33.51
ι Lyræ		03	14.11	.20	14.31	45.94	.37	.42	19	02	45.89
19 Lyræ		07	21.59	.19	21.78	53.36	.42	.42		06	53.36
ω Aquilæ		12	18.72	.14	18.86	50.46	.40	.42		11	50.44
6624 B. A. C		15	11.58	.22	11.80	43.30	.50	.42		14	43.38
δ¹ Aquilæ		19	33.03	.12	33.15	04.71	.44	.42		19	04.73
4 Cygni		22	02.75	.20	02.95	34.52	.43	.42		21	34.53
β¹ Cygni		26	03.79	+0.18	03.93	35.53	−28.40	−28.42	19	25	35.51
λ Ursæ Minoris	19	53	19.8	+6.3	26.1	53.2	....	....	....		
Telescope reversed.											
λ Ursæ Minoris	19	53	18.1	+3.0	21.1	53.2	....	....	....		
o² Cygni	20	10	06.26	+0.06	06.32	38.24	−28.08	−28.20	20	09	38.12
6996 Lalande		14	05.17	.05	05.22	37.07	.19	.20		13	37.02
γ Cygni		18	08.36	.05	08.41	40.21	.20	.20		17	40.21
ε Delphini		27	37.23	.01	36.24	07.98	.26	.20		27	08.04
α Delphini		34	11.93	.02	11.95	43.73	.22	.20		33	43.75
α Cygni	20	37	34.54	+0.06	34.60	06.30	−28.30	−28.20	20	37	06.40
AUGUST 18, 1872.											
Telescope reversed.											
θ Herculis	17	52	22.48	+0.05	22.53	53.37	−29.16	−29.15	17	51	53.38
96 Herculis	17	57	25.50	.03	25.53	56.48	.05	.15	17	56	56.38
98 Herculis	18	01	09.18	.03	09.21	40.14	.07	.15	18	00	40.06
A Herculis		07	35.97	+0.04	36.01	06.83	−29.18	−29.15	18	07	06.86
δ Ursæ Minoris		14	12.2	+1.2	....	44.5	....	....			
109 Herculis		18	45.52	+0.04	45.56	16.28	−29.28	−29.15	18	18	16.41
34128 Lalande		22	14.72	.01	14.73	45.64	.09	.15		21	45.58
34319 Lalande	18	26	48.33	+0.02	48.39	19.12	−29.23	−29.15	18	26	19.20
Telescope direct.											
β¹ Lyræ	18	45	51.92	+0.12	52.04	23.04	−29.00	−29.02	18	45	23.02
δ¹ Lyræ		49	45.92	.13	46.05	17.13	−28.72	.02		49	17.03
γ Lyræ	18	54	40.08	.12	40.20	11.18	−29.02	.02		54	11.18
ζ Aquilæ	19	00	02.52	.08	02.60	33.47	.13	.02	18	59	33.58
ι Lyræ		03	14.81	.13	14.94	45.93	−29.01	.02	19	02	45.92
19 Lyræ		07	22.22	.12	22.34	53.35	−28.99	.02		06	53.32
ω Aquilæ		12	19.43	.07	19.50	50.45	−29.05	.02		11	50.48
6624 B. A. C		15	12.19	.14	12.33	43.29	.04	.02		14	43.31
δ Aquilæ		19	33.72	.06	33.78	04.71	−29.07	.02		19	04.76
4 Cygni		22	03.37	.13	03.50	34.51	−28.99	.02		21	34.48
β¹ Cygni		26	04.37	+0.11	04.48	35.52	−28.96	−29.02	19	25	35.46
λ Ursæ Minoris	19	53	10.4	+5.2	15.6	52.4	....	....	....		
Telescope reversed.											
λ Ursæ Minoris	19	53	18.0	+3.0	21.0	52.4	....	....	....		
ω² Cygni	20	10	07.32	+0.05	07.37	38.23	−29.14	−29.13	20	09	38.24
6996 B. A. C		14	06.16	.04	06.20	37.07	.13	.13		13	37.07
λ Cygni		18	09.27	.04	09.31	40.21	.10	.13		17	40.18
ε Delphini		27	37.17	.00	37.17	07.98	.19	.13		27	08.04
α Delphini		34	12.82	.01	12.83	43.73	.10	.13		33	43.70
α Cygni	20	37	35.39	+0.05	35.44	06.29	−29.15	−29.13	20	37	06.31

Observations with the Gambey meridian-transit and the Morse-Digney chronograph, &c.—Continued.

	Stars.	Observed time of passage.			I.	T.	A_c.	C_p.	C'_p.	Concluded App. AR.		
	AUGUST 19, 1872.											
	Telescope reversed.	*h.*	*m.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*
96	Herculis	17	57	26.32	+0.04	26.36	56.47	—29.89	—30.03	17	56	56.33
98	Herculis	18	00	10.13	.04	10.17	40.12	—30.05	.03	18	00	40.14
A	Herculis		07	36.80	.06	36.86	06.81	.05	.04		07	06.92
6203	B. A. C		12	11.52	.08	11.60	41.49	.11	.04		11	41.56
109	Herculis		18	46.35	+0.05	46.40	16.27	—30.13	—30.04	18	18	16.36
δ	Ursæ Minoris		14	12.9	+1.3	14.2	44.2	....	....	....		
34128	Lalande		22	15.55	+0.02	15.57	45.63	—29.94	—30.04	18	21	45.53
34319	Lalande	18	26	49.18	+0.03	49.21	19.11	—30.10	—30.04	18	26	19.17
	Telescope direct.											
δ[1]	Lyræ	18	49	46.81	+0.17	46.98	17.11	—29.87	—29.88	18	49	47.10
γ	Lyræ	18	54	40.99	.15	41.14	11.16	—29.98	.88		54	11.26
ζ	Aquilæ	19	00	03.40	.10	03.50	33.46	—30.04	.88	18	59	33.62
ι	Lyræ		03	15.54	.17	15.71	45.91	—29.80	.89	19	02	45.82
19	Lyræ		07	23.04	.15	23.19	53.34	.89	.89		06	53.30
ω	Aquilæ		12	20.26	.10	20.36	50.44	.92	.89		11	50.47
6624	B. A. C		15	13.05	.18	13.23	43.27	.96	.89		14	43.34
δ[1]	Aquilæ		19	34.52	.08	34.60	04.70	.90	.90		19	04.70
4	Cygni		22	04.12	.16	04.28	34.50	.78	.90		21	34.38
β	Cygni		26	05.17	+0.14	05.31	35.51	—29.80	—29.90	19	25	35.41
λ	Ursæ Minoris	19	53	15.8	+6.3	22.1	51.6	....	....	....		
	Telescope reversed.											
λ	Ursæ Minoris	19	53	17.4	+3.6	21.0	51.6	....	....	....		
6696	B. A. C	20	14	07.10	+0.06	07.16	37.06	—30.10	—30.08	20	13	37.08
γ	Cygni		18	10.13	.06	10.19	40.20	—29.99	.08		17	40.11
7048	B. A. C		21	59.65	.06	59.71	29.53	—30.18	.08		21	29.63
ε	Delphini		27	38.07	.01	38.08	07.97	.11	.08		27	08.00
α	Delphini		34	13.73	.02	13.79	43.73	.02	.08		33	43.67
α	Cygni	20	37	36.28	+0.07	36.39	06.28	—30.07	—30.08	20	37	06.27
	AUGUST 20, 1872.											
	Telescope reversed.											
θ	Herculis	17	52	24.40	+0.08	24.48	53.33	—31.15	—31.09	17	51	53.39
96	Herculis	17	57	27.37	.05	27.42	56.45	—30.97	.09	17	56	56.33
A	Herculis	18	07	37.82	.07	37.89	06.79	—31.10	.08	18	07	06.81
6203	B. A. C		12	12.56	.08	12.64	41.47	.17	.08	18	11	41.56
106	Herculis		15	25.70	.06	25.76	54.72	.04	.07		14	54.69
109	Herculis	18	18	47.27	+0.06	47.33	16.29	—31.08	—31.07	18	18	16.26
	Telescope direct.											
β	Lyræ	18	45	53.62	+0.20	53.82	23.01	—30.81	—30.84	18	45	22.98
δ	Lyræ		49	47.71	.22	47.93	17.10	.83	.84		49	17.09
γ	Lyræ	18	54	41.79	.20	41.99	11.15	—30.84	.84		54	11.15
ζ	Aquilæ	19	00	04.43	.15	04.58	33.45	—31.13	.83	18	59	33.75
ι	Lyræ		03	16.40	.21	16.61	45.90	—30.71	.83	19	02	45.78
19	Lyræ		07	24.00	.20	24.20	53.32	.88	.83		06	53.37
γ	Aquilæ		40	43.05	.14	43.19	12.49	.70	.81		40	12.38
α	Aquilæ		45	04.93	+0.14	05.07	34.36	—30.71	—30.81	19	44	34.26
λ	Ursæ Minoris	19	53	17.8	+6.3	24.1	50.8	....	....	....		
	Telescope reversed.											
o[2]	Cygni	20	10	09.02	+0.10	09.12	38.20	—30.92	—31.00	20	09	38.12
6996	B. A. C		14	08.10	.09	08.19	37.05	—31.14	.00		13	37.19
γ	Cygni		18	11.07	.10	11.17	40.19	—30.98	—30.99		17	40.18
ε	Delphini		27	39.07	.05	39.12	07.97	—31.15	.99		27	08.13
α	Delphini		34	14.47	.05	14.52	43.72	—30.80	.98		33	43.54
α	Cygni	20	37	37.14	+0.10	37.24	06.27	—30.97	—30.98	20	37	06.26

Table of clock-corrections and hourly rates.

PARIS.

Observations for personal equation, Folain — Blake.—Observer, L. F. Folain.

Date.	Sidereal time.		Correction.	Hourly rate.*
1872.	*h.*	*m.*	*s.*	*s.*
Aug. 16	19	10	—27. 60	—0. 038
17	19	12	—28. 30	—0. 010
18	19	08	—29. 09	+0. 008
19	19	12	—29. 98	—0. 018
20	19	11	—30. 95	+0. 039

*The hourly rate is deduced from the observations at the beginning and close of each night's work, the instrument being in the same position.

Observations with the Gambey meridian-transit for the determination of the difference of longitude between Paris and Greenwich. Observations recorded upon a Morse-Digney chronograph.

Stars.		Observed time of passage.			I.	T.	A_c.	C_p.	C'_p.	Concluded App. AR.		
	AUGUST 28, 1872.											
	Telescope direct.	*h.*	*m.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*
ϱ	Ursæ Minoris	18	13	48. 5	+2. 3	50. 8	40. 8	....	....	....		
34128	Lalande		21	54. 97	+0. 05	55. 02	45. 52	—9. 50	—9. 51	18	21	45. 51
34319	Lalande		26	28. 63	. 07	28. 70	18. 99	. 71	. 51		26	19. 19
34475	Lalande		29	15. 33	. 16	15. 49	05. 77	. 72	. 51		29	05. 98
	Vega		32	47. 15	. 15	47. 30	37. 84	. 46	. 50		32	37. 80
6365	B. A. C		36	02. 76	. 15	02. 91	53. 44	. 47	. 50		35	53. 41
110	Herculis	—	40	20. 10	. 09	20. 19	10. 90	. 29	. 50		40	10. 69
β	Lyræ	18	45	32. 14	+0. 13	32. 27	22. 89	—9. 38	—9. 50	18	45	22. 77
	Telescope reversed.											
α	Lyræ	18	54	20. 53	+0. 01	20. 54	11. 02	—9. 52	—9. 58	18	54	10. 96
19	Lyræ	19	07	02. 87	+0. 01	02. 88	53. 21	. 67	. 57	19	06	53. 31
ω	Aquilæ		11	59. 88	—0. 04	59. 84	50. 36	. 48	. 57		11	50. 27
6624	B. A. C		14	52. 61	+0. 03	52. 64	43. 13	. 51	. 56		14	43. 08
δ[1]	Aquilæ		19	14. 26	—0. 06	14. 20	04. 63	. 57	. 56		19	04. 64
4	Cygni		21	43. 90	+0. 02	43. 92	34. 37	. 55	. 56		21	34. 36
β[1]	Cygni		25	44. 98	—0. 01	44. 97	35. 50	. 47	. 55		25	35. 42
9	Cygni		29	57. 24	. 00	57. 24	47. 65	. 59	. 55		29	47. 69
14	Cygni		35	27. 98	+0. 04	28. 02	18. 36	. 66	. 54		35	18. 48
γ	Aquilæ		40	22. 08	—0. 05	22. 03	12. 43	—9. 60	— 9. 54	19	40	12. 49
λ	Ursæ Minoris	19	52	50. 8	+6. 2	57. 0	44. 0	....	....	....		
	Telescope direct.											
λ	Ursæ Minoris	19	52	43. 9	+8. 3	51. 8	44. 0	....	....	....		
1	Lacertæ	22	10	34. 91	+0. 11	35. 02	25. 82	— 9. 20	— 9. 36	22	10	25. 66
γ	Aquarii		15	14. 52	—0. 03	14. 49	05. 06	. 43	. 36		15	05. 13
4	Lacertæ		19	31. 47	+0. 18	31. 65	22. 26	. 39	. 35		19	22. 30
5	Lacertæ		24	23. 41	+0. 16	23. 57	14. 34	. 23	. 35		24	14. 22
η	Aquarii		28	58. 32	—0. 02	58. 30	49. 03	. 27	. 35		28	48. 95
44252	Lalande		31	50. 12	+0. 13	50. 25	40. 76	. 49	. 34		31	40. 95
ζ	Pegasi	22	35	16. 41	+0. 01	16. 42	06. 96	— 9. 46	— 9. 34	22	35	07. 08
	AUGUST 31, 1872.											
	Telescope direct.											
6624	B. A. C	19	14	56. 95	+0. 18	57. 13	43. 07	—14. 06	—14. 12	19	14	43. 01
δ	Aquilæ		19	18. 60	. 06	18. 66	04. 59	. 07	. 12		19	04. 54
4	Cygni		21	48. 26	. 17	48. 43	34. 32	. 11	. 12		21	34. 31
β[1]	Cygni		25	49. 33	. 13	49. 46	35. 35	. 11	. 12		25	35. 34
9	Cygni	19	30	01. 65	+0. 14	01. 79	47. 60	—14. 19	—14. 12	19	29	47. 67

Observations with the Gambey meridian-transit, &c.—Continued.

Stars.		Observed time of passage.			I.	T.	A_o.	C_p.	C'_p.	Concluded App. AR.		
	AUGUST 31, 1872.											
	Telescope direct—Continued.	*h.*	*m.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*
γ	Aquilæ	19	40	26.49	+0.08	26.57	12.40	−14.17	−14.12	19	40	12.45
λ	Ursæ Minoris	19	52	46.1	+7.8	53.9	40.8	....	....	....		
	Telescope reversed.											
λ	Ursæ Minoris	19	52	46.3	+5.1	51.4	40.8	....	....	....		
o^2	Cygni	20	09	52.07	+0.07	52.14	38.09	−14.09	−14.03	20	09	38.11
6996	B. A. C		13	50.87	.05	50.92	36.92	.00	.03		13	36.89
γ	Cygni		17	54.05	.05	54.10	40.07	−14.03	.03		17	40.07
7048	B. A. C		21	43.24	+0.05	43.39	29.41	−13.98	.03		21	29.36
ε	Delphini		27	21.97	−0.01	21.96	07.93	−14.03	.03		27	07.93
α	Delphini	20	33	57.76	.00	57.76	43.68	.08	.03	20	33	43.73
ξ	Cygni	21	07	45.58	+0.03	45.61	31.49	.12	.03	21	07	31.58
σ	Cygni		12	39.45	+0.05	39.50	25.50	.00	.03		12	25.47
ε	Pegasi		38	10.28	−0.01	10.27	56.23	.04	.03		37	56.24
7593	B. A. C		41	27.95	+0.06	28.01	13.95	.06	.03		41	13.98
14	Pegasi	21	44	27.22	.03	27.25	13.22	−14.03	.03	21	44	13.22
π^2	Pegasi	22	04	34.45	+0.03	34.48	20.52	−13.96	.03	22	04	20.45
γ	Aquarii	22	15	19.13	−0.03	19.10	05.07	−14.03	−14.03	22	15	05.07
	Telescope direct.											
η	Aquarii	22	29	03.07	+0.01	03.08	49.05	−14.03	14.11	22	28	48.97
44252	Lalande		31	54.75	.12	54.87	40.77	.10	.11		31	40.76
ξ	Pegasi		35	21.04	.03	21.07	06.98	.09	.11		35	06.96
λ	Pegasi		40	38.38	.06	38.44	24.29	.15	.11		40	24.33
μ	Pegasi		44	05.94	.06	06.00	51.83	.17	.11		43	51.89
α	Pegasi	22	58	39.54	+0.04	39.58	25.43	−14.15	−14.11	22	58	25.47
	SEPTEMBER 1, 1872.											
	Telescope direct.											
	Aquilæ	19	12	07.10	+0.07	07.17	50.31	−16.86	−16.89	19	11	50.28
624	B. A. C		14	59.81	.14	59.95	43.05	.90	.89		14	43.06
δ	Aquilæ		19	21.45	.06	21.51	04.58	.93	.89		19	04.62
	Cygni		21	51.02	.13	51.15	34.30	.85	.89		21	34.26
β^1	Cygni		25	52.16	.11	52.27	35.34	.93	.89		25	35.38
γ	Aquilæ		40	29.21	+0.07	29.28	12.39	−16.89	−16.89	19	40	12.39
λ	Ursæ Minoris	19	52	49.9	+5.2	55.1	39.8	....	....	....		
	Telescope reversed.											
λ	Ursæ Minoris	19	52	58.0	+2.0	00.0	39.8	....	....	....		
o^2	Cygni	20	09	54.98	+0.03	55.01	38.03	−16.98	−16.96	20	09	38.05
6996	B. A. C		13	53.76	.02	53.78	36.90	−16.88	.96		13	36.82
γ	Cygni		17	57.03	.02	57.05	40.05	−17.05	.96		17	40.09
7048	B. A. C		21	46.41	.02	46.43	29.39	.04	.96		21	29.47
ε	Delphini		27	24.99	.00	24.99	07.92	−17.07	.96		27	08.03
α	Delphini	20	34	00.62	.00	00.62	43.68	−16.94	.96	20	33	43.66
7444	B. A. C	21	19	12.07	.01	12.08	55.23	.85	.95	21	18	55.13
70	Cygni		22	27.28	+0.02	27.30	10.47	16.83	.95		22	10.35
β	Aquarii	21	25	08.58	−0.01	08.57	51.54	−17.03	16.95	21	24	51.62
	Telescope direct.											
7528	B. A. C	21	33	22.23	+0.10	22.33	05.41	−16.92	−16.87	21	33	05.46
ε	Pegasi		38	12.92	.08	13.00	56.23	−16.77	.87		37	56.13
7593	B. A. C		41	30.83	.15	30.98	13.95	−17.03	.87		41	14.11
14	Pegasi		44	29.89	.12	30.01	13.22	−16.79	.87		44	13.14
20	Pegasi		55	10.17	.08	10.25	53.43	.82	.87		54	53.38
α	Aquarii	21	59	31.68	+0.06	31.74	14.87	−16.87	−16.87	21	59	14.87
	SEPTEMBER 7.											
	Telescope direct.											
δ	Aquilæ	19	19	26.62	+0.04	26.66	04.51	−22.15	22.10	19	19	04.56
4	Cygni		21	56.36	.10	56.46	34.19	.27	.10		21	34.36
β^1	Cygni		25	57.26	.08	57.34	35.25	22.09	.11		25	35.23
9	Cygni	19	30	09.40	+0.08	09.48	47.50	−21.98	22.11	19	29	47.37

Observations with the Gambey meridian-transit, &c.—Continued.

	Stars.	Observed time of passage.			I.	T.	A_c.	C_p.	C'_p.	Concluded App. AR.		
	September 7, 1872.											
	Telescope direct—Continued.	h.	m.	s.	s.	s.	s.	s.	s.	h.	m.	s.
14	Cygni	19	35	40.19	+0.11	40.30	18.17	−22.13	−22.12	19	35	18.18
γ	Aquilæ		40	34.30	+0.05	34.35	12.32	−22.03	−22.12	19	40	12.23
λ	Ursæ Minoris	19	52	53.5	+3.6	57.1	34.0	....	....	....		
	Telescope reversed.											
λ	Ursæ Minoris	19	52	49.2	+3.0	52.2	34.0	....	....	....		
ε	Delphini	20	27	30.14	+0.02	30.16	07.87	−22.29	−22.17	20	27	07.99
7114	B. A. C		30	23.26	.06	23.32	01.12	.20	.17		30	01.15
α	Delphini		34	05.75	.03	05.78	43.63	.15	.17		33	43.61
α	Cygni		37	28.16	.07	28.23	06.06	.17	.17		37	06.06
ε	Cygni		41	26.04	.05	26.09	03.97	.12	.18		41	03.91
32	Vulpeculæ	20	49	30.43	.04	30.47	08.34	.13	.18	20	49	08.29
61	Cygni	21	01	34.12	.06	34.18	11.92	.26	.19	21	01	11.99
γ	Pegasi	22	44	14.10	.04	14.14	51.87	.27	.26	22	43	51.88
15	Lacertæ		46	40.46	.06	40.52	18.17	.39	.26		46	18.26
16	Lacertæ		50	57.71	.06	57.77	35.63	.14	.27		50	35.50
α	Pegasi	22	58	47.69	+0.03	47.72	25.48	−22.24	−22.27	22	58	25.45
	Telescope direct.											
7	Andromedæ	23	07	06.04	+0.16	06.20	43.95	−22.25	−22.26	23	06	43.94
λ	Piscium		10	56.30	.06	56.36	34.21	.15	.27		10	34.09
τ	Pegasi		14	42.80	.10	42.90	20.55	.35	.27		14	20.63
υ	Pegasi		19	24.00	.10	24.10	01.92	.18	.27		19	01.83
9	Pegasi		23	05.49	.08	05.57	43.26	.31	.27		22	43.30
ι	Andromedæ	23	32	16.50	+0.14	16.64	54.26	−22.38	−22.28	23	31	54.36
	September 8, 1872.											
	Telescope direct.											
32	Vulpeculæ	20	49	33.23	+0.08	33.31	08.33	−24.98	−25.04	20	49	08.27
ν	Cygni		52	51.09	.11	51.20	26.12	−25.08	.04		52	26.16
7313	Cygni	20	57	53.54	.11	53.65	28.50	.15	.04	20	57	28.61
61	Cygni	21	01	36.82	.10	36.92	11.91	.01	.05	21	01	11.87
γ	Equulei		04	34.17	.05	34.22	09.15	.07	.05		04	09.17
ξ	Cygni	21	07	56.37	−0.08	56.45	31.44	−25.01	−25.05	21	07	31.40
	Telescope reversed.											
15	Pegasi	21	47	14.50	0.00	14.50	49.38	−25.12	−25.10	21	46	49.40
20	Pegasi		55	18.59	−.01	18.58	53.43	.15	.10		54	53.48
α	Aquarii	21	59	40.10	.02	40.08	14.89	.19	.11	21	59	14.97
π²	Pegasi	22	04	45.60	.00	45.60	20.51	.09	.11	22	04	20.49
7757	B. A. C		08	14.13	.00	14.13	49.05	.08	.11		07	49.02
1	Lacertæ		10	50.85	.00	50.85	25.81	.04	.12		10	25.73
γ	Aquarii	22	15	30.20	−0.02	30.18	05.09	−25.09	−25.12	22	15	05.06
	Telescope direct.											
16	Lacertæ	22	51	00.88	+0.14	01.02	35.63	−25.39	−25.11	22	50	35.91
52	Pegasi		53	15.09	.08	15.17	49.92	.25	.11		52	50.06
ο	Andromedæ		56	29.49	.14	29.63	04.51	.12	.11		56	04.52
α	Pegasi	22	58	50.44	.08	50.52	25.48	−25.04	.11	22	58	25.41
7	Andromedæ	23	07	08.64	.16	08.80	43.95	−24.85	.12	23	06	43.68
υ	Pegasi	23	19	26.90	+0.10	27.00	01.93	−25.07	−25.13	23	19	01.87
	September 9, 1872.											
	Telescope direct.											
ω	Aquilæ	19	12	16.00	+0.06	16.06	50.20	−25.86	−25.89	19	11	50.17
6624	B. A. C		15	08.73	.11	08.84	42.88	.96	.89		14	42.95
δ	Aquilæ		19	30.38	.04	30.42	04.48	.94	.89		19	04.53
4	Cygni		21	59.87	.10	59.97	34.15	.82	.89		21	34.08
β¹	Cygni		26	01.01	.08	01.09	35.22	.87	.89		25	35.20
γ	Aquilæ		40	38.19	+0.05	38.20	12.29	−25.91	−25.88	19	40	12.32
λ	Ursæ Minoris	19	52	52.9	+3.6	56.1	31.9	....	....	....		

Observations with the Gambey meridian-transit, &c.—Continued.

	Stars.	Observed time of passage.			I.	T.	A_c.	C_p.	C'_p.	Concluded App. AR.		
	SEPTEMBER 9, 1872.											
	Telescope reversed—Continued.	*h.*	*m.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*
λ	Ursæ Minoris	19	52	52.7	+5.2	57.9	31.9	....	....	....		
o^2	Cygni	20	10	04.11	+0.14	04.25	37.89	−26.36	−26.29	20	09	37.96
6996	B. A. C.		14	02.97	.12	03.09	36.78	.31	.29		13	36.80
γ	Cygni		18	06.21	.12	06.33	39.93	.40	.29		17	40.04
ε	Delphini		27	34.09	.06	34.15	07.85	.30	.29		27	07.86
α	Delphini		34	09.76	.07	09.83	43.61	.22	.29		33	43.54
α	Cygni	20	37	31.94	.14	32.08	06.02	.06	.29	20	37	05.79
η	Aquarii	22	29	15.31	.04	15.35	49.08	.27	.25	22	28	49.10
ζ	Pegasi	22	35	33.29	+0.06	33.35	07.01	−26.34	−26.25	22	35	07.10
	Telescope direct.											
α	Pegasi	22	58	51.22	+0.08	51.30	25.49	−25.81	−25.82	22	58	25.48
4	Andromedæ	23	02	16.53	.15	16.68	50.90	.78	.82	23	01	50.86
7	Andromedæ		07	09.73	.16	09.89	43.95	.94	.82		06	44.07
γ	Piscium		10	59.98	.06	00.04	34.22	.82	.82		10	34.22
υ	Pegasi	23	19	27.60	+0.10	27.70	01.93	−25.77	−25.82	23	19	01.88
	SEPTEMBER 10, 1872.											
	Telescope direct.											
6728	B. A. C.	19	32	56.53	+0.17	56.70	29.64	−27.06	−26.88	19	32	29.82
γ	Aquilæ		40	38.93	.07	39.00	12.28	−26.72	.87		40	12.13
α	Aquilæ		45	00.98	.06	01.04	34.16	.88	−26.87		44	34.17
β	Aquilæ		49	30.12	+0.05	30.17	03.44	−26.73	−26.86	19	49	03.31
λ	Ursæ Minoris	19	52	53.5	+0.8	00.3	30.8	....	....	....		
b^2	Cygni	20	05	09.00	+0.14	09.14	42.20	−26.94	−26.84	20	04	42.30
o^2	Cygni	20	10	04.49	+0.19	04.68	37.86	−26.82	−26.83	20	09	37.85
	Telescope reversed.											
γ	Cygni	20	18	06.85	+0.07	06.92	39.92	−27.00	−27.11	20	17	39.81
ε	Delphini		27	34.85	.01	34.86	07.84	−27.02	.10		27	07.76
7114	B. A. C.		30	27.91	.07	27.98	01.07	−26.91	.10		30	00.88
α	Delphini		34	10.61	.02	10.63	43.60	.03	.09		33	43.54
α	Cygni		37	33.00	.09	33.09	06.01	.08	.09		37	06.00
32	Vulpeculæ	20	49	35.36	+0.04	35.40	08.31	.09	−27.08	20	49	08.32
γ	Aquarii	22	15	32.10	−0.02	32.08	05.09	−26.99	−26.97	22	15	05.11
4	Lacertæ		19	49.21	+0.10	49.31	22.24	−27.07	.97		19	22.34
η	Aquarii		29	16.20	−0.01	16.19	49.08	.11	.96		28	49.23
ζ	Pegasi	22	35	34.12	+0.01	34.13	07.02	−27.11	−26.95	22	35	07.18
	Telescope direct.											
o	Andromedæ	22	56	30.95	+0.15	31.10	04.51	−26.59	−26.63	22	56	04.47
α	Pegasi	22	58	52.09	.06	52.15	25.49	.66	.63	22	58	25.52
4	Andromedæ	23	02	17.15	.16	17.31	50.91	.40	.62	23	01	50.69
7	Andromedæ		07	10.36	.18	10.54	43.96	.58	.62		06	43.92
γ	Piscium		11	00.92	.04	00.96	34.23	.73	.62		10	34.34
υ	Pegasi	23	19	28.60	+0.08	28.68	01.94	−26.74	−26.61	23	19	02.07

LONGITUDE PARIS AND GREENWICH.

Table of clock-corrections and hourly rates at Paris.

Date.		Sidereal time.		Correction.	Hourly rate.*
1872.		*m.*	*s.*	*s.*	*s.*
August	28	20	00	− 9.48	+0.039
	31	21	06	−14.07	0.000
September	1	20	36	−16.92	+0.009
	7	21	24	−22.20	−0.042
	8	22	00	−25.09	−0.035
	9	21	00	−26.04	+0.018
	10	21	24	−26.88	+0.073

* The "hourly-rate" is deduced from the observations made at the beginning and close of each night's work, the instrument being in the same position.

Longitude results. Cambridge — St. Pierre; St. Pierre — Brest; Brest — Greenwich; Brest — Paris; Greenwich — Paris.

RESULTS OF TELEGRAPHIC TIME-SIGNALS EXCHANGED BETWEEN CAMBRIDGE AND ST. PIERRE.

λ = difference of longitude; x = wave and armature time of a time-signal.

Date.	St. Pierre to Cambridge.						Cambridge to St. Pierre.						λ	x
	St. Pierre sidereal time of exchange.	No. of signals.	Mean difference of signals.	Clock-correction. St. Pierre.	Clock-correction. Cambridge. (Sign changed.)	$\lambda - x$	St. Pierre sidereal time of exchange.	No. of signals.	Mean difference of signals.	Clock-correction. St. Pierre.	Clock-correction. Cambridge. (Sign changed.)	$\lambda + x$		
1872.	h. m.		m. s.	s.	s.	m. s.	h. m.		m. s.	s.	s.	m. s.	m. s.	s.
July 21	20 47	60	59 58.244	−14.433	+4.842	59 48.653	21 02	59	59 58.573	−14.426	+ 4.840	59 48.987	[59 48.820] †	0.167
23	21 08	60	56.198	11.904	4.357	48.651	21 23	59	56.463	11.884	4.355	48.934	[48.792] †	0.141
28	21 31	60	50.001	5.041	3.639	48.567*	22 12	59	50.267	4.998	3.640	48.909	59 48.738	0.171
	22 38	20	47.804	4.971	3.640									
29	23 03	57	48.001	3.464	4.072	48.604*	22 50	59	48.306	−3.477	4.065	48.894	48.749	0.145
	23 08	25	47.978	−3.459	4.075									
August 1	22 06	60	39.600	+0.658	8.399	48.657	22 15	59	39.932	+0.666	8.412	49.010	48.833	0.176
6	22 11	60	19.600	7.673	21.202	48.475	22 21	59	19.901	7.680	21.219	48.800	48.637	0.163
9	22 56	60	59 07.112	+11.905	+29.611	59 48.628	23 08	59	59 07.435	+11.915	+29.632	59 48.982	59 48.805	0.177
Mean														0.163

* The value of $\lambda - x$ on July 28 and July 27 has been deduced by giving a weight proportional to the number of signals to the result of each exchange.

† The longitude results on July 21 and 23, although accordant, have been rejected on account of the extreme weakness of the time-determinations at Cambridge. On July 21 four time-stars were observed, but no circumpolars. On July 23 two circumpolars were observed, but only one time-star.

FINAL LONGITUDE RESULTS CAMBRIDGE — ST. PIERRE.

Date.	λ
1872.	m. s.
July 28	59 48.738
29	48.749
Aug. 1	48.833
6	48.637
9	59 48.805
	s.
Mean	59 48.752 ± 0.023

The final observed difference of longitude between the transit-instruments at Cambridge and St. Pierre is—

$$59^{m}\ 48^{s}.752 \pm 0^{s}.023$$

This value has yet to be corrected for the personal-equation difference between the observers, Messrs. Goodfellow and Smith.

RESULTS OF TELEGRAPHIC TIME-SIGNALS EXCHANGED BETWEEN ST. PIERRE AND BREST.

λ = difference of longitude; 2 x = double the wave and armature time of cable-signals plus the sum of Messrs. Goodfellow's and Blake's personal errors in noting them.

Date.	Brest to St. Pierre. Brest sidereal time of exchange.	No. of signals.	Mean difference of signals.	Clock-correction. St. Pierre. (Sign changed.)	Clock-correction. Brest.	λ − x.	St. Pierre to Brest. Brest sidereal time of exchange.	No. of signals.	Mean difference of signals.	Clock-correction. St. Pierre. (Sign changed.)	Clock-correction. Brest.	λ + x.	λ	2 x.	λ Mean result on each date of exchange.
1872.	h. m.		h. m. s.	s.	s.	h. m. s.	h. m.		h. m. s.	s.	s.	h. m. s.	h. m. s.	s.	h. m. s.
July 9	20 39	17	3 26 13.884	+30.528	−0.003	3 26 44.409	20 35	16	3 26 15.146	+30.531	−0.002	3 26 45.675	3 26 45.042	1.266	3 26 45.040
9	20 47	23	13.906	30.522	0.006	44.422	20 43	25	15.134	30.524	0.004	45.654	45.038	1.232	
12	20 30	25	19.978	26.202	1.735	44.445	20 34	23	21.221	26.198	1.737	45.682	45.064	1.237	3 26 45.071
12	20 37	25	20.025	26.195	1.738	44.482	20 56	22	21.254	26.177	1.745	45.686	45.084	1.204	
12	20 59	24	20.038	26.173	1.747	44.464	21 3	23	21.241	26.171	1.748	45.664	45.064	1.200	
14	20 17	24	23.227	23.579	2.172	44.634	20 20	25	24.465	23.578	2.172	45.871	45.252	1.237	3 26 45.272
14	20 24	25	23.254	23.577	2.173	44.658	20 27	25	24.454	23.576	2.173	45.857	45.258	1.199	
14	20 31	23	23.274	23.575	2.174	44.675	20 34	24	24.496	23.574	2.175	45.895	45.285	1.220	
14	20 38	25	23.273	23.573	2.175	44.671	20 41	7	24.517	23.572	2.176	45.913	45.292	1.242	
17	20 34	23	27.766	19.729	2.829	44.666	20 37	24	28.976	19.729	2.829	45.876	45.271	1.210	3 26 45.292
17	20 40	24	27.806	19.729	2.830	44.705	20 44	24	29.003	19.730	2.830	45.903	45.304	1.198	
17	20 47	25	27.833	19.730	2.831	44.732	20 51	25	28.974	19.730	2.831	45.873	45.302	1.141	
18	21 11	25	29.254	18.372	3.056	44.570	21 14	25	30.443	18.369	3.055	45.757	45.164	1.187	3 26 45.162
18	21 18	24	29.275	18.366	3.056	44.585	21 21	24	30.433	18.363	3.056	45.740	45.162	1.155	
18	21 25	24	29.293	18.359	3.057	44.595	21 28	25	30.427	18.356	3.057	45.726	45.160	1.131	
21	20 46	25	33.589	14.534	3.416	44.707	20 50	23	34.803	14.532	3.416	45.919	45.313	1.212	3 26 45.327
21	20 58	24	33.638	14.528	3.418	44.748	21 1	24	34.813	14.527	3.418	45.922	45.335	1.174	
21	21 4	24	33.647	14.525	3.419	44.753	21 8	24	34.812	14.523	3.419	45.916	45.334	1.163	
23	21 2	19	36.636	12.112	4.078	44.670	21 7	19	37.824	12.109	4.080	45.853	45.262	1.183	3 26 45.263
23	21 11	25	36.639	12.106	4.081	44.664	21 15	22	37.833	12.104	4.082	45.855	45.260	1.191	
23	21 19	19	36.648	12.101	4.082	44.667	21 23	24	37.844	12.098	4.083	45.859	45.263	1.192	
23	21 28	23	3 26 36.650	+12.095	−4.085	3 26 44.660	21 32	23	3 26 37.864	+12.092	−4.085	3 26 45.871	3 26 45.266	1.211	
Mean														1.199	

FINAL LONGITUDE RESULTS ST. PIERRE — BREST.

Date.	λ	Weight.
1872.	h. m. s.	
July 9	3 26 45.040	0.5
12	45.071	0.5
14	45.272	1.0
17	45.292	1.0
18	45.162	1.0
21	45.327	1.0
23	3 26 45.263	1.0
Mean	3 26 45.229 ± 0.025 (s.)	

The final observed difference of longitude between the transit-instruments at St. Pierre and Brest is—

$$3^h\ 26^m\ 45^s.229 \pm 0^s.025$$

This value has yet to be corrected for the personal-equation difference between the observers, Messrs. Goodfellow and Blake, and for half the difference of their personal errors in noting the cable-signals.

RESULTS OF TELEGRAPHIC TIME-SIGNALS EXCHANGED BETWEEN BREST AND PARIS.

λ = difference of longitude; x = wave and armature time of a time-signal.

Date.	Paris to Brest.						Brest to Paris.									
	Brest sidereal time of exchange.	No. of signals.	Mean difference of signals, corrected for Paris pen-error.	Clock-correction. Paris.	Clock-correction. Brest. (Sign changed.)	$\lambda - x$.	Brest sidereal time of exchange.	No. of signals.	Mean difference of signals, corrected for Paris pen-error.	Clock-correction. Paris.	Clock-correction. Brest. (Sign changed.)	$\lambda + x$.	λ	x.	λ Mean result on each date of exchange.
1872.	h. m.		m. s.	s.	s.	m. s.	h. m.		m. s.	s.	s.	m. s.	m. s.	s.	m. s.
July 1	15 23	30	27 32.981	−10.985	−3.795	27 18.201	15 26	25	27 33.007	−10.984	−3.794	27 18.229	27 18.215	0.014	27 18.228
1	17 20	30	32.906	10.938	3.754	18.214	17 35	25	32.947	10.932	3.749	18.266	18.240	0.026	
3	15 32	30	48.469	27.461	2.795	18.213	15 35	23	48.539	27.458	2.795	18.286	18.250	0.036	18.268
3	17 26	26	48.355	27.336	2.761	18.253	17 30	23	48.404	27.332	2.760	18.312	18.285	0.027	
4	16 8	12	38.574	18.000	2.403	18.171	16 12	27	38.597	17.999	2.402	18.196	18.184	0.012	18.188
4	17 35	24	38.529	17.985	2.380	18.164	17 41	29	38.584	17.984	2.378	18.222	18.193	0.029	
5	15 44	30	40.834	20.570	2.000	18.264	16 1	30	40.933	20.574	2.004	18.355	18.310	0.046	18.314
5	17 43	30	40.833	20.601	1.973	18.259	17 46	30	40.949	20.602	1.972	18.375	18.317	0.058	
9	15 58	27	39.257	20.918	0.091	18.248	16 1	30	39.342	20.915	0.090	18.337	18.292	0.044	18.360
9	17 59	30	39.237	20.799	−0.050	18.388	18 1	30	39.317	20.797	−0.050	18.470	18.429	0.041	
19	19 53	30	19.931	4.800	+3.018	18.149	19 57	30	20.010	4.799	+3.019	18.230	18.190	0.040	18.190
20	20 3	30	22.532	7.505	3.283	18.310	20 7	30	22.582	7.503	3.284	18.363	18.336	0.026	18.336
21	20 2	30	22.054	7.298	3.409	18.165	20 12	30	22.136	7.299	3.411	18.248	18.206	0.042	18.206
22	20 3	30	7 21.572	− 7.188	+3.722	27 18.106	20 15	30	27 21.684	− 7.190	+3.725	27 18.219	27 18.162	0.056	27 18.162
Mean														0.036	

FINAL LONGITUDE RESULTS BREST—PARIS.

Date.	λ	Date.	λ
1872.	m. s.	1872.	m. s.
July 1	27 18.228	July 20	27 18.336
3	18.268	21	18.206
4	18.188	22	27 18.162
5	18.314		
9	18.360	Mean	27 18.250 ± 0.016
19	27 18.190		

The final observed difference of longitude between the transit-instruments at Brest and Paris is—

$$27^m\ 18^s.250 \pm 0^s.016$$

This value has yet to be corrected for the personal-equation difference between the observers, Messrs. Folain and Blake.

RESULTS OF TELEGRAPHIC TIME-SIGNALS EXCHANGED BETWEEN BREST AND GREENWICH.

λ = difference of longitude; x = wave and armature time of a time-signal.

Date.	Greenwich to Brest. Brest sidereal time of exchange.	No. of signals.	Mean difference of signals.	Clock-correction. Brest. (Sign changed.)	Clock-correction. Greenwich.	$\lambda - x$.	Brest to Greenwich. Brest sidereal time of exchange.	No. of signals.	Mean difference of signals.	Clock-correction. Brest. (Sign changed.)	Clock-correction. Greenwich.	$\lambda + x$.	λ	x.
1872.	*h. m.*		*m. s.*	*s.*	*s.*	*m. s.*	*h. m.*		*m. s.*	*s.*	*s.*	*m. s.*	*m. s.*	*s.*
July 1	17 55	30	17 13.593	− 3.742	+47.246	17 57.097	18 1	30	17 13.688	−3.740	+47.246	17 57.194	17 57.146	0.048
3	18 2	30	12.328	2.750	47.488	57.066	18 8	30	12.437	2.749	47.489	57.177	57.122	0.056
4	18 7	30	11.684	2.371	47.767	57.080	18 13	30	11.760	2.370	47.767	57.157	57.118	0.038
5	18 10	30	11.101	−1.965	47.900	57.036	18 16	30	11.134	−1.963	47.900	57.071	57.054	0.018
11	18 34	30	17 7.478	+0.947	+48.526	17 56.951	18 37	30	17 7.627	+0.949	+48.526	17 57.102	17 57.026	0.076
Mean														0.047

FINAL LONGITUDE RESULTS BREST—GREENWICH.

Date.	λ
1872.	*m. s.*
July 1	17 57.146
3	57.122
4	57.118
5	57.054
11	57.026
Mean	17 57.093 ± 0.015

The final observed difference of longitude between the transit-instruments at Brest and Greenwich is—

$$17^{m}\ 57^{s}.093 \pm 0^{s}.015.$$

This value has yet to be corrected for the personal-equation difference between the observers, "Greenwich standard observer" and Blake.

RESULTS OF TELEGRAPHIC TIME-SIGNALS EXCHANGED BETWEEN GREENWICH (COAST-SURVEY TRANSIT) AND PARIS.

Date.	Paris to Greenwich.						Greenwich to Paris.						λ	x.
	Greenwich sidereal time of exchange.	No. of signals.	Mean difference of signals, corrected for Paris pen-error.	Clock-correction. Paris.	Clock-correction. Greenwich. (Sign changed.)	λ − x.	Greenwich sidereal time of exchange.	No. of signals.	Mean difference of signals, corrected for Paris pen-error.	Clock-correction. Paris.	Clock-correction. Greenwich. (Sign changed.)	λ + x.		
1872.	h. m.		m. s.	s.	s.	m. s.	h. m.		m. s.	s.	s.	m. s.	m. s.	s.
Aug. 28	21 39	42	9 32.081	− 9.410	−1.737	9 20.934	21 46	40	9 32.255	− 9.405	−1.737	9 21.113	9 21.024	0.090
31	21 13	28	37.212	14.070	2.247	20.895	21 24	41	37.383	14.070	2.249	21.064	20.980	0.084
Sept. 7	22 1	39	48.854	22.232	5.615	21.007	22 13	41	48.987	22.241	5.621	21.125	21.066	0.059
9	21 20	17	53.858	26.031	6.975	20.852	22 2	40	54.018	26.018	6.994	21.006	20.929	0.077
10	21 46	35	9 55.445	−26.842	−7.638	9 20.965	21 51	35	9 55.519	−26.836	−7.640	9 21.043	9 21.004	0.039
Mean														0.070

FINAL LONGITUDE RESULTS GREENWICH — PARIS.

Date.	λ
1872.	m. s.
Aug. 28	9 21.024
31	20.980
Sept. 7	21.066
9	20.929
10	21.004
	s.
Mean	9 21.001 ± 0.016

As the Coast-Survey transit was $0^s.160$ east of the Greenwich transit-circle the mean longitude obtained above must be increased by that amount. This having been done, the final observed difference of longitude between the transit-instruments at Greenwich and Paris is—

$$9^m\ 21^s.161 \pm 0^s.016$$

This value has yet to be corrected for the personal-equation difference between the observers, Messrs. Folain and Blake.

Results of observations for personal error in noting cable time-signals at St. Pierre and Brest.

This subject is fully discussed in Section VII. Below is given a set as observed by Mr. Goodfellow at St. Pierre, after which only the mean of each set is given.

PERSONAL ERROR IN NOTING CABLE TIME-SIGNALS AT ST. PIERRE.

Observer, Edward Goodfellow.—July 26, 1872.

Set No. 1.

Time of signal.	Time of noting.	Diff.	Time of signal.	Time of noting.	Diff.
h. m. s.	*s.*	*s.*	*h. m. s.*	*s.*	*s.*
9 21 57.92	58.52	0.60	9 23 03.07	03.39	0.32
9 22 02.92	03.40	.48	08.11	08.36	.25
07.80	08.21	.41	13.07	13.29	.22
13.00	13.29	.39	17.91	18.17	.26
17.91	18.20	.29	23.00	23.30	.30
22.90	23.19	.29	28.20	28.48	.28
28.00	28.24	.24	33.11	33.41	.30
32.98	33.24	.26	38.12	38.50	.38
38.00	38.29	.29	43.31	43.53	.22
43.00	43.27	.27	48.11	48.39	.28
47.80	48.10	.30	53.08	53.36	.28
52.82	53.10	.28	9 23 58.09	58.40	0.31
9 22 58.00	58.33	0.33			0.313

Results of observations for personal error in noting cable time-signals, &c —**Continued.**

The following are the mean results of each set:

Date.	No. of set.	Time.	No. of observations in set.	Diff.	Date.	No. of set.	Time.	No. of observations in set.	Diff.
1872.		*h. m.*		*s.*			*h. m.*		*s.*
July 26	I.	9 22	25	0.313	July 27	VI.	11 27	24	0.260
	II.	38	23	.271		VII.	11 29	25	.256
	III.	45	25	.264	July 29	I.	13 16	25	.263
	IV.	47	18	.249		II.	18	23	.270
	V.	50	22	.224		III.	28	25	.268
	VI.	52	22	.268		IV.	30	25	.258
	VII.	54	25	.260		V.	33	24	.248
	VIII.	9 56	24	.239		VI.	35	25	.256
	IX.	10 02	23	.277		VII.	37	25	.239
	X.	10 05	25	.276		VIII.	45	25	.263
July 26	I.	12 54	25	.260		IX.	50	25	.254
	II.	13 10	25	.295		X.	13 55	25	.266
	III.	24	25	.256		XI.	14 05	25	.272
	IV.	27	25	.250		XII.	11	16	.283
	V.	30	25	.235		XIII.	15	24	.274
	VI.	41	24	.253		XIV.	14 18	25	.268
	VII.	44	24	.237	July 30	I.	7 54	25	.262
	VIII.	50	25	.246		II.	7 56	20	.243
	IX.	13 52	25	.265		III.	8 03	21	.274
July 27	I.	11 12	25	.246		IV.	05	12	.258
	II.	14	24	.248		V.	14	24	.272
	III.	20	23	.258		VI.	8 16	25	0.253
	IV.	23	25	.240					*s.*
	V.	11 25	25	0.229				1,090	0.259 ± 0.002

PERSONAL ERROR IN NOTING CABLE TIME-SIGNALS.

Observer, F. Blake, jr.—Brest, France.

Date.	Time.	No. of observations.	Diff.
1872.	*h. m.*		*s.*
July 24	4 30 p. m.	44	0.244
24	10 00 p. m.	44	.230
25	4 00 p. m.	44	0.239
			s.
		132	0.238 ± 0.004

Results of observations for personal-equation differences between the transatlantic longitude observers of 1872.

DIFFERENCE OF PERSONAL EQUATION BETWEEN MESSRS. FOLAIN AND BLAKE.

Results of telegraphic time-signals at Paris between *la lunette méridienne* and the Coast-Survey transit.—Coast-Survey transit 0s.005 west of *lunette méridienne*.

Date.	Folain to Blake.						Blake to Folain.						Blake west of Folain. λ	x.
	Sidereal time of exchange.	No. of signals.	Mean difference of signals, corrected for Folain's pen-error.	Clock-correction. Folain.	Clock-correction. Blake. (Sign changed.)	Blake west of Folain. $\lambda - x$.	Sidereal time of exchange.	No. of signals.	Mean difference of signals, corrected for Folain's pen-error.	Clock-correction. Folain.	Clock-correction. Blake. (Sign changed.)	Blake west of Folain. $\lambda + x$.		
1872.	*h. m.*		*s.*	*s.*	*s.*	*s.*	*h. m.*		*s.*	*s.*	*s.*	*s.*	*s.*	*s.*
August 16	20 52	21	+26.091	−27.665	+1.452	−0.122	20 55	39	+26.062	−27.666	+1.451	−0.153	−0.138	−0.016
17	20 51	30	+27.069	−28.316	.320	+0.073	20 54	32	+27.065	−28.317	.320	+0.068	+0.070	.002
18	20 45	24	+27.930	−29.077	.339	.182	20 48	31	+27.901	−29.077	.329	.153	.168	.014
19	20 43	20	+28.707	−30.007	.396	.096	20 46	31	+28.663	−30.008	.395	.050	.073	.023
20	20 41	21	+29.424	−30.892	+1.547	+0.079	20 44	29	+29.374	−30.890	+1.547	+0.031	+0.055	−0.024
Mean														−0.016

FINAL PERSONAL-EQUATION RESULTS FOLAIN − BLAKE.

Date.	Blake west of Folain.
1872.	*s.*
August 16	− 0.138
17	+ 0.070
18	.168
19	.073
20	+ 0.055
Mean	+ 0.046 ± 0.034

The mean observed difference of longitude 0s.016 ± 0s.034 diminished by 0s.005—the actual distance in longitude between the two transit-instruments—gives the finally-adopted personal-equation difference:

Blake west of Folain, 0s.041 ± 0s.034.

It is obvious that an observed difference of longitude between these two observers must be *increased* or *diminished* according as Blake occupies the *eastern* or *western* station.

DIFFERENCE OF PERSONAL EQUATION BETWEEN THE "GREENWICH STANDARD OBSERVER" (MR. CRISWICK) AND MR. BLAKE.

Results of telegraphic time-signals between the Greenwich transit-circle and the Coast-Survey transit.—Transit 0s.160 east of transit-circle.

Date.	Greenwich observer.	Greenwich observer to Blake.						Blake to Greenwich observer.						Mean: Blake east of Greenwich standard observer.	x.
		Sidereal time of exchange.	Number of signals.	Mean difference of signals.	Clock-correction.		Blake east of Greenwich standard observer.	Sidereal time of exchange.	Number of signals.	Mean difference of signals.	Clock-correction.		Blake east of Greenwich standard observer.		
					Blake.	Greenwich observer reduced to standard. (Sign changed.)	$\lambda + x$.				Blake.	Greenwich observer reduced to standard. (Sign changed.)	$\lambda - x$.	λ	
1872.		h. m.		s.	s.	s.	s.	h. m.		s.	s.	s.	s.	s.	s.
August 28	J. C.	20 53	19	+40.985	+1.735	—42.476	+0.244	21 18	30	+40.986	+1.736	—42.490	+0.232	+0.238	+0.006
30	L.	21 5	24	+42.242	+1.895	—43.825	.312	21 8	27	+42.231	+1.895	—43.826	.300	.306	.006
31	E.	21 41	24	.382	+2.254	—44.344	.292	21 44	26	.378	+2.255	—44.345	.288	.290	.002
September 3	H. C.	20 51	29	.670	+3.756	—46.257	.169	20 55	30	.652	+3.758	—46.258	.152	.160	+0.008
4	L.	20 54	30	+42.886	+4.153	—46.754	.285	20 58	30	+42.887	+4.155	—46.756	.286	.286	.000
5	J.	22 13	25	+43.086	+4.548	—47.441	.193	22 16	26	+43.066	+4.549	—47.442	.173	.183	+0.010
6	J. C.	21 13	28	+46.484	+5.019	—51.371	.132	21 16	22	+46.460	+5.020	—51.372	.108	.120	+0.012
7	E. & P.	22 36	30	+42.355	+5.630	—47.848	.137	22 39	30	+42.379	+5.630	—47.848	.162	.150	—0.012
9	E.	22 20	27	+41.584	+7.002	—48.311	+0.275	22 23	26	+41.551	+7.003	—48.312	+0.242	+0.258	+0.016
Mean															+0.005

FINAL PERSONAL-EQUATION RESULTS, GREENWICH STANDARD OBSERVER — BLAKE.

Date.	Blake east of Greenwich standard observer.	Date.	Blake east of Greenwich standard observer.	Date.	Blake east of Greenwich standard observer.
1872.	s.	1872.	s.	1872.	s.
August 28	+ 0.238	September 3	+ 0.160	September 6	+ 0.120
30	.306	4	.286	7	.150
31	+ 0.290	5	+ 0.183	9	+ 0.258
Mean					+ 0.221 ± 0s.016

The mean observed difference of longitude 0s.221 ± 0s.016 diminished by 0s.160—the actual distance in longitude between the two transit-instruments—gives the finally-adopted personal-equation difference:

Blake east of Greenwich standard observer, 0s.061 ± 0s.016.

It is obvious that an observed difference of longitude between these two observers must be *diminished* or *increased* according as Blake occupies the *eastern* or *western* station.

PERSONAL EQUATION.

GOODFELLOW, BLAKE AND SMITH.

After the return of the European party, Messrs. Goodfellow, Blake, and Smith assembled at Cambridge to observe for personal equation. The three instruments used in the longitude-work were set up in the same meridian. Each observer used the instrument he had had in the field, and determined independently, from the same stars, the error of the south clock of the Harvard Observatory, a relay, breaking three circuits, enabling them to note the time entirely independent of each other.

The following are the observations from which the personal equation is derived. Transit No. 6 was used by Mr. Goodfellow, No. 5 by Mr. Smith, and No. 4 by Mr. Blake. The clock-correction is deduced from stars whose declinations are less than 65°.

Observations for personal equation, Cambridge, Mass., October and November, 1872.

Date.	Star.	No. of transit.	Lp.	Observed time of transit.	Correction.					Clock-time of meridian-transit.	Right ascension.	Clock-correction.
					Rate.	Aberration.	Level.	Azimuth.	Collimation.			
1872.				h. m. s.	s.	s.	s.	s.	s.	h. m. s.	h. m. s.	s.
Oct. 19	1 Draconis, L. C....	5	W.	21 18 36.83	−0.02	+0.11	−0.77	....	....	....	21 18 41.08	....
		6	W.	33.78	.02	.11	+ .08					
		4	W.	34.96	.02	+ .11	+ .22					
	β Cephei...........	5	W.	26 53.24	.01	− .04	+ .48			....	27 01.22	
		6	W.	54.23	.01	.04	− .08					
		4	W.	53.80	.01	.04	− .14					
	ξ Aquarii..........	5	W.	30 51.33	.01	.02	+ .11	−0.38	−0.08	21 30 50.95	30 58.22	+7.27
		6	W.	51.03	.01	.02	− .02	− .05	− .04	50.89		7.33
		4	W.	51.12	.01	.02	− .04	− .16	+ .04	50.93		7.29
	ε Pegasi..........	5	W.	37 48.79	.01	.02	+ .14	− .27	− .08	37 48.55	37 55.87	7.32
		6	W.	48.61	.01	.02	− .04	− .05	− .04	48.45		7.42
		4	W.	48.68	.01	.02	− .05	− .11	+ .04	48.53		7.34
	μ Capricorni.......	5	W.	46 14.27	.01	.02	+ .08	− .41	− .08	46 13.82	46 21.13	7.31
		6	W.	14.01	.01	.02	− .02	− .06	− .04	13.86		7.27
		4	W.	14.06	−.01	.02	− .03	− .17	+ .04	13.86		7.27
	α Aquarii..........	5	W.	59 07.67	.00	.02	+ .10	− .33	− .08	59 07.34	59 14.64	7.30
		6	E.	07.27	.00	.02	+ .04	− .04	+ .04	07.29		7.34
	ι Pegasi...........	5	W.	22 00 57.98	.00	.02	+ .14	− .16	− .09	22 00 57.85	22 01 05.09	7.24
		6	E.	57.65	.00	.02	+ .05	− .02	+ .05	57.71		7.38
	θ Pegasi...........	5	W.	03 39.65	.00	.02	+ .11	− .29	− .08	03 39.37	03 46.66	7.29
		6	E.	39.31	.00	.02	+ .04	− .03	+ .04	39.34		7.32
		4	W.	39.44	.00	.02	− .04	− .12	+ .04	39.30		7.36
	θ Aquarii..........	5	E.	09 59.79	.00	.02	+ .13	− .32	+ .08	09 59.66	10 06.88	7.22
		6	E.	59.67	.00	.02	+ .02	− .04	+ .04	59.67		7.21
		4	E.	59.78	.00	.02	− .02	− .10	− .04	59.60		7.28
	π Aquarii..........	5	E.	18 39.32	.00	.02	+ .15	− .26	+ .08	18 39.27	18 46.58	7.31
		6	E.	39.24	.00	.02	+ .02	− .04	+ .04	39.25		7.33
		4	E.	39.41	.00	− .02	− .03	−0.09	−0.04	39.23		+7.35
	9 Draconis, L. C ...	5	E.	24 01.13	+ .01	+ .07	− .41	....	....	....	24 09.24	
		6	E.	02.33	.01	.07	− .04					
		6	W.	02.00	.01	.07	+ .07					
		4	E.	02.21	.01	+ .07	+ .10					
	226 Cephei..........	5	E.	29 54.52	.01	− .06	+ .66	....	....	....	30 03.65	
		6	W.	56.64	.01	.06	− .12					
		4	E.	56.57	.01	.06	− .17					
	ζ Pegasi...........	5	E.	34 59.52	.01	.02	+ .17	−0.22	+0.08	22 34 59.54	35 06.89	+7.35
		6	W.	59.67	.01	.02	− .03	− .04	− .04	59.55		7.34
		4	E.	59.73	.01	.02	− .05	− .07	− .04	59.56		7.33
	λ Aquarii..........	5	E.	45 51.33	.01	.02	+ .14	− .32	+ .08	45 51.24	45 58.49	7.25
		6	W.	51.35	.01	.02	− .02	− .06	− .04	51.22		7.27
		4	E.	51.35	.01	.02	− .04	− .10	− .04	51.16		7.33
	α Pegasi..........	5	E.	58 18.12	.02	.02	+ .22	− .19	+ .08	58 18.23	58 25.42	7.19
		6	W.	18.29	.02	.02	− .03	− .04	− .04	18.18		7.24
		4	E.	58 18.28	+0.02	−0.02	−0.04	−0.06	−0.04	18.14		+7.28

Observations for personal equation, Cambridge, Mass., &c.—Continued.

Date.	Star.	No. of transit.	Lp.	Observed time of transit.	Correction. Rate.	Aberration.	Level.	Azimuth.	Collimation	Clock-time of meridian-transit.	Right ascension.	Clock-correction.
1872.				h. m. s.	s.	s.	s.	s.	s.	h. m. s.	h. m. s.	s.
Oct. 21	11 Cephei..........	5	E.	21 39 53.81	−0.02	−0.05	+0.52	......	......	....	21 40 03.63	
		6	E.	55.30	.02	.05	− .03					
		4	E.	55.51	.02	.05	− .12					
	μ Capricorni.......	5	E.	46 13.27	.01	.02	+ .11	−0.52	+0.06	21 46 12.89	46 21.10	+8.21
		6	E.	12.80	.01	.02	− .01	+ .02	+ .05	12.83		8.27
		4	E.	12.92	.01	.02	− .03	− .04	− .05	12.77		8.33
	α Aquarii..........	5	E.	59 06.53	.01	.02	+ .14	− .42	+ .06	59 06.28	59 14.61	8.33
		6	E.	06.13	.01	.02	− .01	+ .02	+ .05	06.16		8.45
		4	E.	06.34	.01	.02	− .03	− .04	− .05	06.19		8.42
	ι Pegasi..........	5	E.	22 00 56.71	.01	.02	+ .20	− .20	+ .07	22 00 56.75	22 01 05.06	8.31
		6	E.	56.61	.01	.02	− .02	+ .01	+ .05	56.62		8.44
		4	E.	56.86	.01	.02	− .03	− .02	− .06	56.72		8.34
	θ Pegasi..........	5	E.	03 38.45	.01	.02	+ .15	− .37	+ .06	03 38.26	03 46.64	8.38
		6	E.	38.17	.01	.02	− .01	+ .02	+ .05	38.20		8.44
		4	E.	38.35	.01	.02	− .02	− .03	− .05	38.22		8.42
	θ Aquarii..........	5	W.	09 58.89	.01	.02	+ .14	− .40	− .06	09 58.54	10 06.86	8.32
		6	E.	58.48	.01	.02	− .01	+ .02	+ .05	58.51		8.35
		4	W.	58.75	− .01	.02	− .03	− .14	+ .05	58.60		8.26
	π Aquarii..........	5	W.	18 38.53	.00	.02	+ .16	− .34	− .06	18 38.27	18 46.56	8.29
		6	E.	38.07	.00	.02	− .01	+ .02	+ .05	38.11		8.45
		4	W.	38.19	.00	− .02	− .03	− .12	+ .05	38.07		+8.49
	9 Draconis, L. C ...	5	W.	24 03.15	.00	+ .07	− .42	......	......	....	24 09.41	
		6	E.	01.06	.00	.07	+ .02					
		6	W.	00.27	.00	+ .07	+ .17					
		4	W.	01.80	.00	− .06	+ .07					
	226 Cephei..........	5	W.	29 53.75	.00	.06	+ .68	......	......	....	30 03.52	
		6	W.	55.94	.00	.06	− .29					
		4	W.	54.73	.00	.06	− .10					
	ζ Pegasi.	5	W.	34 58.74	.00	.02	+ .17	− .28	− .06	22 34 58.55	35 06.87	+8.32
		6	W.	58.51	.00	.02	− .07	+ .05	− .05	58.42		8.45
		4	W.	58.55	.00	.02	− .02	− .10	+ .05	58.46		8.41
	λ Aquarii..........	5	W.	45 50.53	.00	.02	+ .13	− .40	− .06	45 50.18	45 58.48	8.30
		6	W.	50.21	.00	.02	− .06	+ .07	− .05	50.15		8.33
		4	W.	50.27	.00	.02	− .01	− .14	+ .05	50.15		8.33
	α Pegasi..........	5	W.	58 17.22	+ .01	.02	+ .17	− .24	− .56	58 17.08	58 25.41	8.33
		6	W.	17.05	.01	.02	− .09	+ .04	− .05	16.95		8.46
		4	W.	17.03	.01	.02	− .02	− .09	+ .05	16.96		+8.45
	ε Cephei..........	5	W.	23 13 16.49	.02	.04	+ .43	......	......	....	23 13 25.58	
		6	W.	17.68	.02	− .04	− .29					
	λ Draconis, L. C ...	6	W.	23 37.50	+ .02	+ .05	+ .14	......	......	....	23 46.30	
Oct. 28	α Aquarii..........	5	W.	21 59 02.98	− .03	− .02	+ .25	+ .03	− .02	21 59 03.19	21 59 14.52	+11.33
		6	W.	03.32	.03	.02	− .04	− .12	− .06	03.05		11.47
		4	W.	03.30	.03	.02	− .07	− .19	+ .08	03.07		11.45
	ι Pegasi..........	5	W.	22 00 53.38	.03	.02	+ .36	+ .01	− .02	22 00 53.68	22 01 04.96	11.28
		6	W.	53.76	.03	.02	− .06	− .06	− .07	53.52		11.14
	θ Pegasi..........	6	W.	03 35.27	.03	.02	− .05	− .10	− .06	03 35.01	03 46.56	11.55
	θ Aquarii..........	5	W.	10 55.18	.02	.02	+ .21	+ .03	− .02	10 55.36	10 06.78	11.42
		6	W.	55.75	.02	.02	− .04	− .13	− .06	55.48		11.30
		4	W.	55.59	.02	.02	− .05	− .21	+ .08	55.37		11.41
	π Aquarii..........	5	W.	18 34.73	.02	.02	+ .25	+ .03	− .02	18 34.95	18 46.48	11.53
		6	W.	35.22	.02	.02	− .04	− .12	− .06	34.96		11.52
		4	W.	35.22	.02	− .02	− .07	− .18	+ .08	35.01		+11.47
	9 Draconis, L. C ...	5	W.	23 59.18	.02	+ .06	− .67	......	......	....	24 10.05	
		6	W.	58.72	.02	.06	+ .09					
		4	W.	59.87	.02	+ .06	+0.20					
	226 Cephei..........	5	W.	29 50.91	.01	− .06	+1.10	......	......	....	30 03.04	
		6	W.	51.51	.01	.06	−0.14					
		6	E.	51.00	.01	.06	+ .10					
		4	W.	51.28	−0.01	−0.06	−0.32					

Observations for personal equation, Cambridge, Mass., &c.—Continued.

Date.	Star.	No. of transit.	Lp.	Observed time of transit.			Correction. Rate.	Aberration.	Level.	Azimuth.	Collimation.	Clock-time of meridian-transit.			Right ascension.			Clock-correction.
1872.				h.	m.	s.	s.	s.	s.	s.	s.	h.	m.	s.	h.	m.	s.	s.
Oct. 28.	ζ Pegasi	5	W.	22	34	55.16	−0.01	−0.02	+0.28	+0.02	−0.02	22	34	55.41	22	35	06.80	+11.39
		6	E.			55.35	.01	.02	+ .03	− .06	+ .06			55.35				11.45
		4	W.			55.53	− .01	.02	− .08	− .15	+ .08			55.35				11.45
	λ Aquarii	5	E.		45	46.64	.00	.02	+ .28	+ .18	+ .02		45	47.10		45	58.41	11.31
		6	E.			47.01	.00	.02	+ .02	− .09	+ .06			46.98				11.43
		4	E.			47.31	.00	.02	− .06	− .15	− .08			47.00				11.41
	α Pegasi	5	E.		58	13.45	+ .01	.02	+ .39	+ .12	+ .02		58	13.97		58	25.34	11.37
		6	E.			13.86	.01	.02	+ .04	− .06	+ .06			13.89				11.45
		4	E.			14.11	.01	.02	−0.10	− .09	− .08			13.83				11.51
	ο Cephei	5	E.	23	13	13.11	.02	.04	+1.02	......	......	......			23	13	25.36	
		6	E.			13.64	.02	.04	+0.06									
		4	E.			14.22	.02	.04	− .31									
	υ Pegasi	5	E.		18	49.99	.02	.02	+ .45	+ .09	+ .02	23	18	50.55		19	01.87	11.32
		6	E.			50.40	.02	.02	+ .02	− .04	+ .07			50.45				11.42
		4	E.			50.78	.02	− .02	− .14	− .07	− .09			50.48				+11.39
	λ Draconis, L. C.	5	E.		23	35.08	.02	+ .04	− .51	......	......	......				23	46.75	
		6	E.			35.70	.02	.04	− .01									
		4	E.			35.34	.02	+ .04	+0.17									
	γ Cephei	5	E.		34	58.20	.03	− .07	+1.71	......	......	......				34	10.79	
		6	E.			58.78	.03	.07	+0.01									
		6	W.			59.83	.03	.07	− .27									
		4	E.			59.82	.03	.07	− .54									
	φ Pegasi	5	E.		45	49.15	.04	.02	+ .45	+ .10	+ .02	23	46	49.74		45	01.12	+11.38
		6	W.			49.86	.04	.02	− .07	− .02	− .07			49.72				11.40
		4	E.			50.10	.04	.02	− .13	− .08	− .08			49.83				11.29
	ω Piscium	5	E.		52	34.92	.04	.02	+ .38	+ .14	+ .02		52	35.48		52	46.79	11.31
		6	W.			35.56	.04	.02	− .06	− .03	− .06			35.43				11.36
		4	E.	23	52	35.69	+ .04	.02	− .10	− .11	− .08			35.42				11.37
Oct. 29	α Aquarii	5	E.	21	59	02.09	− .03	.02	+ .05	− .05	+ .04	21	59	02.08	21	59	14.51	12.43
		6	E.			02.26	.03	.02	+ .03	− .22	+ .01			02.03				12.48
		4	E.			02.51	.03	.02	− .10	− .17	− .05			02.14				12.37
	1 Pegasi	5	E.	22	00	52.50	.03	.02	+ .08	− .03	+ .05	22	00	52.55	22	01	04.95	12.40
		6	E.			52.61	.03	.02	+ .05	− .11	+ .01			52.51				12.44
		4	E.			53.00	.03	.02	− .14	− .08	− .05			52.68				12.27
	θ Pegasi	5	E.		03	34.08	.03	.02	+ .07	− .05	+ .04		03	34.09		03	46.54	12.45
		6	E.			34.26	.03	.02	+ .04	− .19	+ .01			34.07				12.47
		4	E.			34.55	.03	.02	− .11	− .15	− .05			34.19				12.35
	θ Aquarii	5	E.		09	54.38	.03	.02	+ .06	− .06	+ .04		09	54.37		10	06.77	12.40
		6	E.			54.69	.03	.02	+ .02	− .25	+ .01			54.42				12.35
		4	E.			54.84	.03	.02	− .10	− .19	− .05			54.45				12.32
	π Aquarii	5	E.		18	33.93	.02	.02	+ .08	− .05	+ .04		18	33.96		18	46.47	12.51
		6	E.			34.21	.02	.02	+ .01	− .22	+ .01			33.97				12.50
		4	E.			34.54	.02	−0.02	− .12	−0.16	−0.05			34.17				+12.30
	9 Draconis, L. C.	5	E.		24	58.41	.02	+0.07	− .25	......	......	......				24	10.14	
		6	E.			58.88	.02	.07	− .04									
		4	E.			58.09	.02	+0.07	+ .33									
	226 Cephei	5	E.		29	49.85	.01	−0.06	+ .46	......	......	......				30	02.97	
		6	E.			49.40	.01	.06	+ .07									
		6	W.			50.74	.01	.06	− .08									
		4	E.			50.77	.01	.06	− .51									
	ζ Pegasi	5	E.		34	54.19	.01	.02	+ .13	−0.04	+0.04	22	34	54.29		35	06.79	+12.50
		6	W.			54.68	.01	.02	− .02	− .11	− .08			54.44				12.35
		4	E.			54.87	−0.01	.02	− .13	− .13	− .05			54.53				12.26
	λ Aquarii	5	W.		45	46.02	.00	.02	+ .03	+ .05	− .04		45	46.04		45	58.40	12.36
		6	W.			46.32	.00	.02	− .01	− .16	− .08			46.05				12.35
		4	W.			46.31	.00	.02	− .07	− .25	+ .05			46.02				12.38
	α Pegasi	5	W.		58	12.89	+0.01	.02	+ .06	+ .03	− .05		58	12.92		58	25.33	12.41
		6	W.			13.22	.01	.02	− .02	− .10	− .08			13.01				12.32
		4	W.			13.34	+0.01	−0.02	−0.10	−0.16	+0.05			13.12				+12.21

Observations for personal equation, Cambridge, Mass., &c.—Continued.

Date.	Star.	No. of transit.	Lp.	Observed time of transit.			Correction.					Clock-time of meridian-transit.			Right ascension.			Clock-correction.
							Rate.	Aberration.	Level.	Azimuth.	Collimation.							
				h.	m.	s.	s.	s.	s.	s.	s.	h.	m.	s.	h.	m.	s.	s.
1872. Oct. 29	ο Cephei......	5	W.	23	13	12.97	+0.02	—0.04	+0.25	—0.12	......	......			23	13	25.32	
		6	W.			12.98	.02	.04	—0.56									
		4	W.			12.88	.02	.04	—0.26									
	υ Pegasi......	5	W.		18	49.42	.02	.02	+0.11	+0.02	—0.05	23	19	49.50		18	01.86	+12.36
		6	W.			49.65	.02	.02	—0.03	—0.07	—0.09			49.46				12.40
		4	W.			49.71	.02	— .02	— .12	—0.12	+0.05			49.52				+12.34
	λ Draconis, L. C....	5	W.		23	33.79	.02	+ .04	—0.12	......	......	......				23	46.80	
		6	W.			34.50	.02	.04	+0.03									
		4	W.			35.33	.02	+ .04	+ .14									
	γ Cephei......	5	W.		33	57.94	.03	— .07	+0.40	......	......	......				34	10.74	
		6	W.			58.03	.03	.07	—0.09									
		6	E.			57.73	.03	.07	+0.16									
		4	W.			57.92	.03	.07	—0.47									
	φ Pegasi......	5	W.		45	48.58	.04	.02	+0.11	+0.03	—0.05	23	45	48.69		46	01.12	+12.43
		6	E.			48.74	.04	.02	+0.05	—0.03	+0.09			48.87				12.25
		4	W.			49.03	.04	.02	—0.12	—0.14	+0.05			48.84				12.28
	ω Piscium......	5	W.		52	34.31	.04	.02	+0.09	+0.04	—0.04		52	34.42		52	46.79	12.37
		6	E.			34.48	.04	.02	+0.04	—0.05	+0.09			34.58				12.21
		4	W.			34.58	+0.04	.02	—0.09	—0.19	+0.05			34.37				12.42
Nov. 1	α Pegasi......	5	W.	22	58	10.77	—0.01	.02	— .06	+0.01	—0.06	22	58	10.63	22	58	25.30	14.67
		6	W.			10.58	.01	.02	—0.01	+0.02	—0.04			10.52				14.78
		4	W.			10.59	.01	.02	+0.05	—0.15	+0.08			10.54				+14.76
	ο Cephei......	5	W.	23	13	10.94	.01	.04	—0.11	......	......	......			23	13	25.22	
		6	W.			11.05	.01	.04	—0.04									
		4	W.			09.94	.01	.04	+0.12									
	υ Pegasi......	5	W.		18	47.22	.01	.02	—0.02	+0.01	—0.06	23	18	47.12		19	01.83	+14.71
		6	W			47.07	.01	.02	—0.02	+0.02	—0.05			46.99				14.84
		4	W.			47.01	— .01	.02	+0.05	—0.11	+0.08			47.02				14.81
	θ Piscium......	5	W.		21	16.24	.00	.02	—0.01	+0.01	—0.06		21	16.16		21	30.87	14.71
		6	W.			16.06	.00	.02	—0.02	+0.03	—0.04			16.01				14.86
		4	W.			16.16	.00	.02	+0.03	—0.18	+0.07			16.06				+14.81
	γ Cephei......	5	W.		33	56.39	.00	.07	—0.15	......	......	......				34	10.56	
		6	W.			56.10	.00	.07	—0.12									
		6	E.			55.50	.00	.07	+0.09									
		4	W.			54.60	.00	.07	+0.12									
	ω Piscium......	5	W.		52	32.17	+ .01	.02	—0.01	+0.01	—0.06	23	52	32.10		52	46.77	+14.67
		6	E.			32.03	.01	.02	+0.02	.00	+0.04			32.08				14.69
		4	W.			32.10	.01	.02	+0.02	—0.18	+ .07			32.00				14.77
	α Andromedæ......	5	E.	0	01	34.15	.01	.02	—0.01	—0.01	+ .07	0	01	34.19	0	01	48.97	14.78
		6	E.			34.10	.01	.02	+0.03	.00	+0.05			34.17				14.80
		4	E.			34.31	.01	.02	+0.05	— .09	—0.08			34.18				14.79
	γ Pegasi......	5	E.		06	26.49	.02	.02	—0.01	— .02	+0.06		06	26.52		06	41.28	14.76
		6	E.			26.40	.02	.02	+0.03	.00	+0.04			26.47				14.81
		4	E.			26.67	.02	.02	+ .04	— .16	—0.08			26.47				14.81
	ι Ceti......	5	E.		12	42.17	.02	.02	.00	— .03	+0.06		12	42.20		12	56.97	14.77
		6	E.			42.11	.02	.02	+ .01	.00	+0.04			42.16				14.81
		4	E.			42.41	.02	— .02	+0.02	—0.27	—0.07			42.09				+14.88
	κ Draconis, L. C....	5	E.		27	44.70	.02	+ .05	—0.03	......	......	......				27	59.26	
		6	E.			44.60	.02	.05	— .02									
		4	E.			45.06	.02	+ .05	—0.03									
	21 Cassiopeæ......	5	E.		37	04.58	.03	— .06	+0.06	......	......	......				37	18.78	
		6	E.			04.37	.03	.06	+0.07									
		6	W.			05.01	.03	.06	—0.05									
		4	E.			04.27	.03	— .06	+0.08									
	32 Camelop., L. C...	5	E.		47	50.73	.03	+ .15	—0.09	......	......	......				48	04.44	
		4	E.			51.65	.03	+ .15	—0.14									
	ε Piscium......	5	E.		56	05.99	.04	.02	+0.01	—0.02	+0.06	0	56	06.06		56	20.75	+14.69
		6	W.			06.01	+0.04	—0.02	—0.01	+0.08	—0.03			06.07				+14.68

Observations for personal equation, Cambridge, Mass., &c.—Continued.

Date.	Star.	No. of transit.	Lp.	Observed time of transit.			Correction. Rate.	Correction. Aberration.	Correction. Level.	Correction. Azimuth.	Correction. Collimation.	Clock-time of meridian-transit.			Right ascension.			Clock-correction.
				h.	m.	s.	s.	s.	s.	s.	s.	h.	m.	s.	h.	m.	s.	s.
1872. Nov. 2	9 Draconis, L. C ...	5	E.	22	23	56. 80	−0. 03	+0. 07	−0. 01	...	......	...	...	...	22	24	10. 53	
		6	E.			59. 83	. 03	. 07	− . 02									
		4	E.			55. 96	. 03	+ . 07	+ . 01									
	ξ Pegasi..........	5	E.		34	51. 74	. 02	− . 02	+ . 01	0. 16	+0. 08	22	34	51. 63		35	06. 75	+15. 12
		6	E.			51. 52	. 02	. 02	− . 01	+ . 08	+ . 04			51. 59				15. 16
		4	E.			51. 95	. 02	. 02	− . 01	− . 11	− . 06			51. 73				15. 02
	λ Aquarii..........	5	E.		45	43. 35	. 02	. 02	. 00	− . 23	+ . 07		45	43. 15		45	58. 35	15. 20
		4	E.			43. 50	. 02	. 02	− . 01	− . 16	− . 06			43. 23				15. 12
	α Pegasi	5	E.		58	10. 07	. 01	. 02	− . 02	− . 14	+ . 08		58	09. 96		58	25. 29	15. 33
		6	E.			10. 12	. 01	. 02	. 00	+ . 07	+ . 04			00. 20				15. 09
		4	E			10. 48	. 01	. 02	− . 02	−0. 10	−0. 06			10. 27				+15. 02
	ο Cephei	5	E.	23	13	09. 78	. 01	. 04	− . 02	......	......	...	...	...	23	13	25. 18	
		6	E.			10. 16	. 01	. 04	− . 02									
		4	E.			10. 32	− . 01	. 04	− . 07									
	υ Pegasi..........	5	E.		18	46. 64	. 00	. 02	− . 01	−0. 10	+0. 08	23	18	46. 59		19	01. 82	+15. 23
		6	E.			46. 62	. 00	. 02	− . 01	+ . 05	+ . 05			46. 69				15. 13
		4	E.			46. 87	. 00	. 02	− . 03	− . 07	− . 07			46. 68				15. 14
	θ Piscium	5	E.		21	15. 67	. 00	. 02	. 01	− . 17	+ . 07		21	15. 54		21	30. 86	15. 32
		6	E.			15. 60	. 00	. 02	. 00	+ . 09	+ . 04			15. 71				15. 15
		4	E.			15. 92	. 00	. 02	− . 02	−0. 12	−0. 06			15. 70				+15. 16
	γ Cephei..........	5	W.		33	55. 66	. 00	. 07	− . 13	......	......	...	...	...		34	10. 50	
		6	E.			55. 65	. 00	. 07	− . 01									
		6	W.			56. 39	. 00	. 07	− . 18									
		4	W.			54. 75	. 00	. 07	+ . 01									
	φ Pegasi..........	5	W.		45	46. 03	+ . 01	. 02	− . 04	−0. 03	−0. 08	23	45	45. 83		46	01. 09	+15. 22
		6	W.			45. 96	. 01	. 02	− . 05	+ . 08	− . 05			45. 93				15. 16
		4	W.			46. 01	. 01	. 02	+ . 01	− . 08	+ . 06			45. 99				15. 10
	ω Piscium..........	5	W.		52	31. 74	. 01	. 02	− . 04	− . 04	− . 07		52	31. 58		52	46. 77	15. 19
		6	W.			31. 68	. 01	. 02	− . 04	+ . 12	− . 04			31. 71				15. 06
		4	W.			31. 75	. 01	. 02	+ . 01	− . 11	+ . 06			31. 70				15. 07
	α Andromedæ	5	W.	0	01	33. 97	. 01	. 02	− . 04	− . 02	− . 09	0	01	33. 81	0	01	48. 96	15. 15
		6	W.			33. 76	. 01	. 02	− . 06	+ . 06	− . 05			33. 70				15. 26
		4	W.			33. 84	. 01	. 02	+ . 02	− . 05	+ . 07			33. 87				15. 09
	γ Pegasi..........	5	W.		06	26. 20	. 02	. 02	− . 03	− . 03	− . 08		06	26. 06		06	41. 28	15. 22
		6	W.			26. 11	. 02	. 02	− . 05	+ . 10	− . 04			26. 12				15. 16
		4	W.			26. 36	. 02	. 02	+ . 02	− . 09	+ . 06			26. 35				14. 93
	ι Ceti	5	W.		12	41. 88	. 02	. 02	. 00	− . 06	− . 08		12	41. 74		12	56. 96	15. 22
		4	W.			41. 91	. 02	− . 02	+ . 02	+0. 15	+0. 06			41. 84				+15. 12
	κ Draconis, L. C ...	6	W.		27	43. 43	. 02	+ . 05	+ . 06	......	......	...	...	...		27	59. 30	
		4	W.			44. 90	+0. 02	+0. 05	−0. 02									

RESULTS OF OBSERVATIONS FOR PERSONAL EQUATION BETWEEN MESSRS. GOODFELLOW, BLAKE AND SMITH.

Date.	Sidereal time.	Clock-correction.			Smith − Blake.			Goodfellow − Smith.			Goodfellow − Blake.		
		Smith.	Goodfellow	Blake.	$\Delta T_S - \Delta T_B$	Corrected for difference in circuit.	S − B.	$\Delta T_G - \Delta T_S$	Corrected for difference in circuit.	G − S.	$\Delta T_G - \Delta T_B$	Corrected for difference in circuit.	G − B.
1872.	h. m.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
Oct. 19	22 06	+ 7.277	+ 7.314	+ 7.314	−0.037	+0.032	− 0.005	+0.037	−0.033	+0.004	0.000	−0.001	−0.001
21	22 25	8.310	8.404	8.383	.073	.010	.063	.094	.025	.069	+ .021	−0.015	+ .006
28	22 48	11.364	11.435	11.417	− .053	.001	− .052	+ .071	.000	+ .071	.018	+ .001	.019
29	22 48	12.420	12.375	12.317	+ .103	.010	+[.113]	− .045	.019	−[.064]	+ .058	− .009	+ .049
Nov. 1	23 58	14.720	14.784	14.804	− .084	.009	− .075	+ .064	.007	+ .057	− .020	+ .002	− .018
2	23 29	+15.220	+15.146	+15.077	+0.143	−0.008	+[0.151]*	−0.074	−0.010	−[0.084]	+0.069	−0.002	+0.067

* Mr. Smith suffering with a severe headache throughout the night's work.

The finally-adopted values (see Section XI of this report) are—

	s. s.
Blake east of Smith	0.042 ± 0.010
Blake west of Goodfellow	0.015 ± 0.009
Smith west of Goodfellow	0.057 ± 0.011

LIST OF SKETCHES.

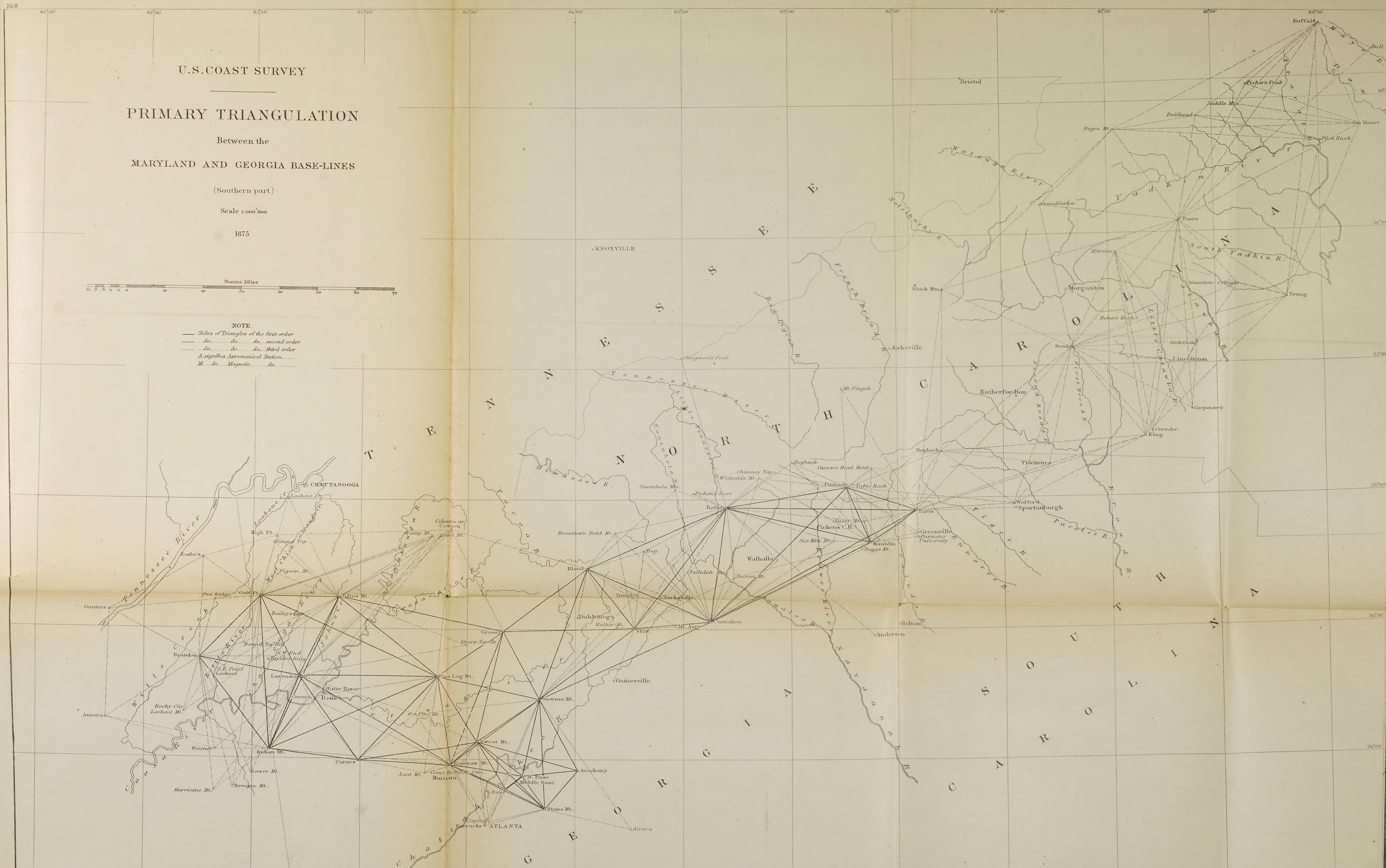
PROGRESS SKETCHES.

ILLUSTRATIONS.


No. 3
U. S. COAST SURVEY
Sketch B No. 3
Showing the
TRIANGULATION & GEOGRAPHICAL POSITIONS
IN
SECTION No. II
From New York City to Cape Henlopen
Scale 1/400,000
1875
Signifies Lines between primary occupied stations
do. do. do. secondary do. do.
Ch. do. Church
Ho. do. House
H. do. Hill
N. do. Neck
Signifies Light House
do. Cupola or Spire
do. Signal
Note. A complete resurvey of New York Bay and Harbor; both topographic and hydrographic, was made in 1855_'57.
The Channels have been sounded frequently since. A resurvey of the shoreline and wharves of New York Harbor was made in 1875.
PENNSYLVANIA
NEW JERSEY
DELAWARE
DELAWARE BAY
ATLANTIC OCEAN
Statute Miles


No 3
U.S. COAST SURVEY
PRIMARY TRIANGULATION
Between the
MARYLAND AND GEORGIA BASE-LINES
(Northern part)
Scale 1/1 000 000
1875
Statute Miles
NOTE
Sides of Triangles of the first order
do. do. do. second order
do. do. do. third order
A signifies Astronomical Station
M. do. Magnetic do.
P E N N S Y L V A N I A
M A R Y L A N D
V I R G I N I A
W E S T V I R G I N I A
Billsboro
Ragged
Frazer
Bedford
Rickey
Reeves
Mt. Washington
Roxbury
White Horse
Martin Mt.
Garner
Negro
Savage
Frostburg
Cumberland
Hancock
Fairview
Town Hill
Martinsburg
Shepherdstown
Smith Mtn.
High Knob
Frederick
Cacapon
Round Top
Maryland Heights
Catoctin
Charlestown
Sugarloaf
Lockard
Winchester
Nat. Cem.
Berryville
Leesburg
Stabler
Webb
Swan Pt.
Linstid
Rockville
Soper
Newtown
Taylor
N. Base
Kent I. Base
S. Base
Annapolis
Strasburg
Paris
Middleburg
Peach Grove
Capitol
Hill
WASHINGTON
Marriott
Bull Run
Alexandria
Theol. Semy.
Poplar I.
Mt. Marshall
Warrenton
Blake
Panther Knob
Slate Springs
Harrisonburg
Fork
Culpeper C.H.
Madison C.H.
Clark
Fredericksburg
Orange C.H.
Summersville C.H.
Paddy's Knob
Briery Knob
Elliott's Knob
Staunton
Gordonsville
University of Va.
Charlottesville
Louisa C.H.
Humpback
Bald Knob
Keeney's Knob
Spear
Buckingham C.H.
Willis
Apple Orchard Mt.
Tobacco Row
Amherst C.H.
Flat Top
Lynchburg
Weaver's Knob
Liberty
Campbell C.H.
Long Mt.
Pilot
Johnson's Mt.
Cahas
Blackwater R.
Smiths
Chestnut Mt.
Turkey Cock
Buffalo
Bull Mt.
Chestnut Knob
Fisher's Peak
Saddle Mt.
Bullhead
Negro Mt.
Moore

No 9



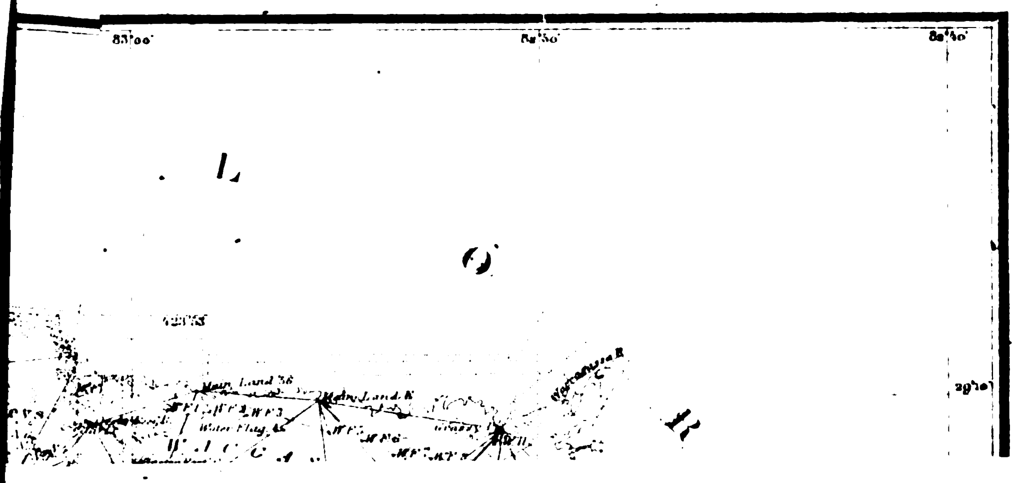
U.S. COAST SURVEY
PRIMARY TRIANGULATION
Between the
MARYLAND AND GEORGIA BASE-LINES
(Southern part)
Scale 1:1000000
1875
Statute Miles
NOTE
Sides of Triangles of the first order
do. do. do. second order
do. do. do. third order
A signifies Astronomical Station.
M do. Magnetic do.
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
KNOXVILLE
CHATTANOOGA
ATLANTA
Bristol
Asheville
Morganton
Rutherfordton
Lincolnton
Spartanburgh
Greenville
Anderson
Belton
Walhalla
Clarksville
Dahlonega
Gainesville
Marietta
Rome
Buffalo
Moore
Pilot Knob
Fisher's Peak
Saddle Mt.
Bullhead
Negro Mt.
Grandfather
Yadkin River
South Yadkin R.
Young
Black Mtn.
Bakers Knob
Anderson
Carpenter's
Crowder
King
Hogback
Thickety
Wofford
Paris
Pinnacle
Table Rock
Caesars Head Hotel
Chimney Top
Whiteside Mt.
Pickens C.H.
Six Mile Mt.
Mauldin
Boggs Mt.
Rabun
Pickens Nose
Nantahela Mts.
Brasstown Bald Mt.
Blood
Yonah
Tallulah
Currahee
Mt. Airy
Skitt
Walker Mt.
Grassy
Sharp Top Mt.
Pine Log Mt.
Sawnee Mt.
Sweat Mt.
Kenesaw Mt.
Lost Mt.
Academy
N. Base
Middle Base
Stone Mt.
Capitol
Barracks
Alcova
Carnes
Indian Mt.
Lavender Mt.
Johns Mt.
Gaits Pt.
Pea Ridge
Pigeon Mt.
Round Top
High Pt.
Lookout Pt.
Cohutta or Cowpen
Bald Mt.
Grassy Mt.
Kashe's
Gunters
Brandon
Aurora
Rocky City Lookout Mt.
Weisner
Lower Mt.
Terrapin Mt.
Hurricane Mt.
Water Tower
Coosa
Tennessee River
Tennessee River
Savannah R.
Broad R.
Catawba R.
French Broad R.
Watauga River
Dan R.
Hiwassee R.
Clingman's Peak
Mt. Pisgah


U.S. COAST SURVEY
PROGRESS SKETCH SEC. VI
EAST COAST OF FLORIDA
FROM AMELIA ISLAND TO HALIFAX RIVER
Scale 1/200,000
1875
NOTE
A. Signifies Astronomical Station
M......do......Magnetic............do.....
......do.... Lines between Secondary occupied Stations
.....do.......do.......do...........do...........do......and unoccupied Stations
......do.......do.......do...........do.......unoccupied Stations
......do.......do.......do.....Tertiary occupied Stations
......do.......do.......do.........do.........do......and unoccupied Stations
......do.......do......do.........do....unoccupied Stations
.......do.....Limits of Topographic Sheets
.......do.......do........Hydrographic Sheets
Vertical figures designate the number of Topographic Sheets
Inclined...do..........do................do.........Hydrographic Sheets
The broken shore line is unsurveyed
Statute Miles
Florida Railroad
Nassau Inlet
St. Johns River
St. Augustine Inlet
Matanzas Inlet
Anastasia Island
Jacksonville
Haulover
Halifax
30°30'
30°20'
30°10'
30°00'
29°50'
29°40'
29°30'
29°20'
81°40'
81°30'
81°20'
81°10'

U. S. COAST SURVEY
PROGRESS SKETCH SEC. VI
EAST COAST OF FLORIDA
HALIFAX RIVER TO CAPE CANAVERAL
Scale 200,000
1875
Hercules
Halifax
Homer
Pine Pt.
Chaucer
Orange I.
Molleson
Daytona
Bethune Pt.
Dobbin
M^c Daniel
Patroclus
Mosquito Inlet
Oceola
N. Base
Palo Blanco
S. Base
New Smyrna
Palo Alto
Palo Negro
Los Pinos
St. Agnan
Turtle Mound
Wallace
Bear
MOSQUITO LAGOON
Deer
Whale
Head
S. E. Base
Black Pt.
River
Panther
INDIAN RIVER
Sand Pt.
Titusville
Wild Cat
Banana Creek
MERRITT'S I.
BANANA RIVER
Canaveral Lt. Ho.
NOTE
A. Signifies Astronomical Station
M. do. Magnetic do.
do. Lines between Secondary occupied Stations
do. do. do. do. do. and unoccupied Stations
do. do. do. do. unoccupied Stations
do. do. do. Tertiary occupied Stations
do. do. do. do. do. and unoccupied Stations
do. do. do. do. unoccupied Stations
do. Limits of Topographic Sheets
do. do. Hydrographic Sheets
Vertical figures designate the number of Topographic Sheets
Inclined do. do. do. Hydrographic Sheets
The broken shore line is unsurveyed
Statute Miles
81°00'
80°50'
80°40'
80°30'
29°20'
29°10'
29°00'
28°50'
28°40'
28°30'
28°20'
28°10'
28°00'

No. 12

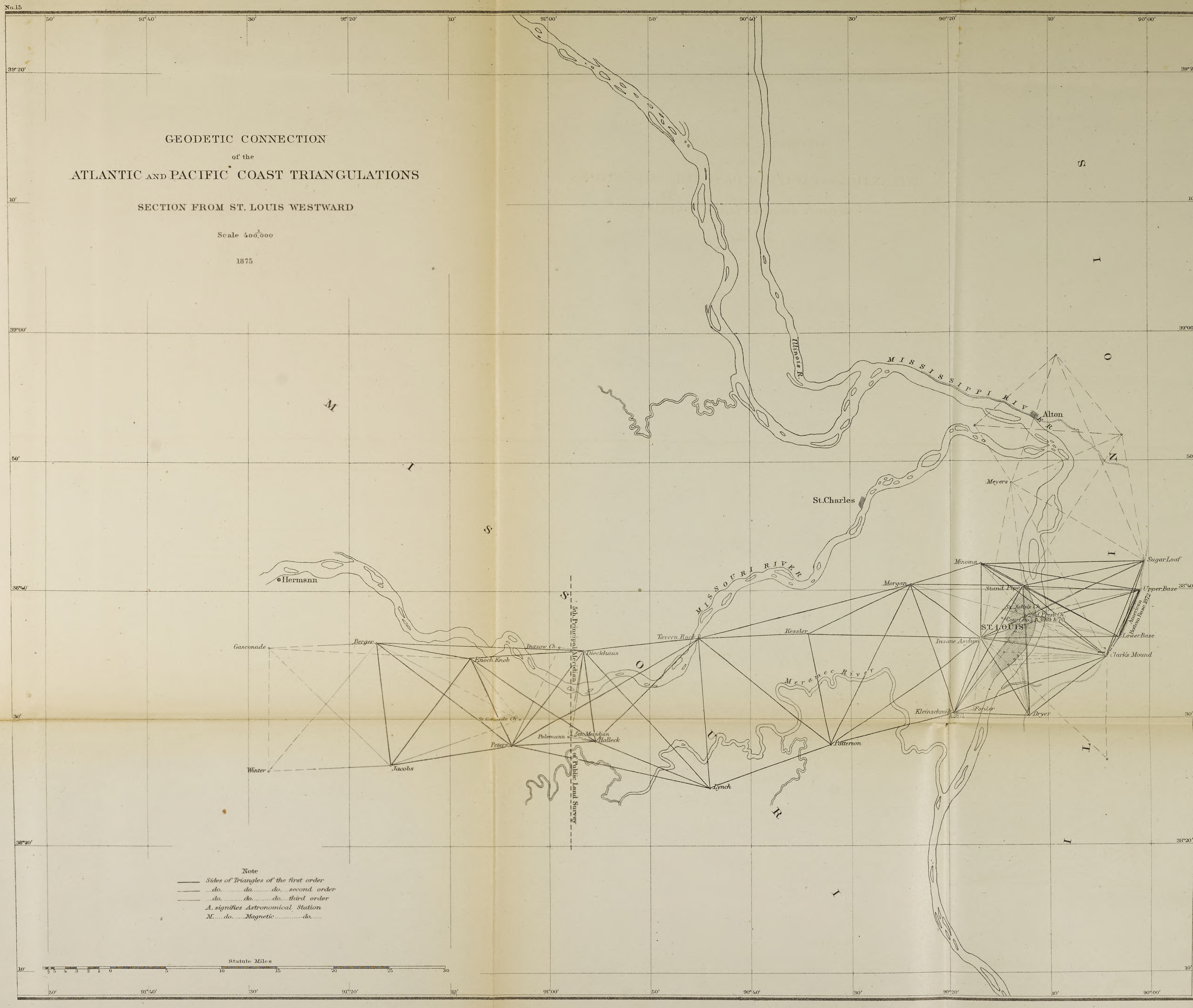
U. S. COAST SURVEY
PROGRESS SKETCH SEC. VI
WEST COAST OF FLORIDA
TAMPA BAY AND VICINITY
Scale 1/200,000
1875
NOTE
A. Signifies Astronomical Station
M. do. Magnetic do.
do. Lines between Secondary occupied Stations
do. do. do. do. do. and unoccupied Stations
do. do. do. do. unoccupied Stations
do. do. do. Tertiary occupied Stations
do. do. do. do. do. and unoccupied Stations
do. do. do. do. unoccupied Stations
do. Limits of Topographic Sheets
do. do. Hydrographic Sheets
Vertical figures designate the number of Topographic Sheets
Inclined do. do. do. Hydrographic Sheets
The broken shore line is unsurveyed
Statute Miles
ST. JOSEPHS BAY
OLD TAMPA BAY
HILLSBORO BAY
TAMPA BAY
SARASOTA BAY
Manatee River
Tampa
Manatee
Palmetto
Maximo Pt.
Bird Key
Pine Key
Bush Key
Mullet Key
Egmont Key
Main Ship Channel
Passage Key Inlet
Anna Maria Key
Terraceia Bay
Palmasola Bay
Longboat Inlet
New Pass
Big Sarasota Pass
Johns Pass
Blind Pass
Indian Pass
Little Pass
Pass-a-Grille
Long Key
Mangrove Pt.
Ballast Pt.
Hooker's Pt.
Little Mangrove
Clearwater Bluff
N. Base
S. Base
N. W. Base
S. E. Base
83°00'
82°50'
82°40'
82°30'
82°20'
28°10'
28°00'
27°50'
27°40'
27°30'
27°20'
27°10'
27°00'
26°50'


83°00'
82°50'
82°40'
29°10'
Main Land 56
Main Land K

14

87°30'

31°00'


No. 15
GEODETIC CONNECTION
of the
ATLANTIC AND PACIFIC COAST TRIANGULATIONS
SECTION FROM ST. LOUIS WESTWARD
Scale $\frac{1}{400,000}$
1875
MISSISSIPPI RIVER
MISSOURI RIVER
Illinois R.
Meramec River
Alton
St. Charles
ST. LOUIS
Hermann
Gasconade
Berger
Enoch Knob
Dutzow Ch.
Dieckhaus
Tavern Rock
Kessler
Morgan
Minoma
Sugar Loaf
Upper Base
Stand Pipe
Lower Base
Clark's Mound
Insane Asylum
Meyers
Kleinschmidt
Dryer
Patterson
Lynch
Halleck
5th Meridian
Polemann
Peters
Jacobs
Winter
5th Principal Meridian of Public Land Survey
Note
Sides of Triangles of the first order
...do. ... do. ... do. ... second order
...do. ... do. ... do. ... third order
A. signifies Astronomical Station
M. ... do. ... Magnetic ... do.
Statute Miles
MISSOURI
ILLINOIS

16

No. 18

Sub Sketch
COQUILLE RIVER
OREGON
Scale $\frac{1}{120,000}$
1860
Magnetic Meridian
P A C I F I C O C E A N
C A L I F O R N I A
San Francisco Entrance
Mt. Diablo
Sulphur Peak
Sonoma Mt.
Tomales Bay
Pt. Sal
(J bis)
U. S. COAST SURVEY
Sketch J
SHOWING THE PROGRESS OF THE SURVEY
IN
SECTION No. X
(Middle Sheet)
FROM PT. SAL TO TOMALES BAY
From 1850 to 1875
Scale $\frac{1}{600,000}$
1875
Notes
A Signifies Astronomical Station
M. do. Magnetic do.
T. do. Tidal do.
X do. Current do.
do. Lines between Primary occupied Stations
do. do. do. do. do. and unoccupied Stations
do. do. do. do. unoccupied Stations
do. do. do. Secondary occupied Stations
do. do. do. do. do. and unoccupied Stations
do. do. do. do. unoccupied Stations
do. do. do. Tertiary occupied Stations
do. do. do. do. do. and unoccupied Stations
do. do. do. do. unoccupied Stations
do. Limits of Topographic Sheets
do. do. Hydrographic do.
Vertical figures designate the number of Topographic Sheet
Inclined do. do. do. Hydrographic Sheet
The dotted shore line is unsurveyed
Statute Miles

No. 19


U. S. COAST SURVEY
PROGRESS OF THE SURVEY IN
SECTION No. XI
(Lower Sheet)
FROM THE CALIFORNIA LINE TO TILLAMOOK BAY
Scale 1/600,000
1875
NOTES
A. Signifies Astronomical Station
M. do. Magnetic do.
do. Lines between Primary occupied Stations
do. do. do. do. do. and unoccupied Stations
do. do. do. do. unoccupied Stations
do. do. do. Secondary occupied Stations
do. do. do. do. do. and unoccupied Stations
do. do. do. do. unoccupied Stations
do. do. do. Tertiary occupied Stations
do. do. do. do. do. and unoccupied Stations
do. do. do. do. unoccupied Stations
do. Limits of Topographic Sheets
do. do. Hydrographic Sheets
Vertical figures designate the number of Topographic Sheets
Inclined do. do. do. Hydrographic Sheets
The broken shore line is unsurveyed
Cape Meares
Cape Lookout
Nestuggah River
Yaquina Point
Alseya River
Cape Perpetua
Umpquah River
Ten Mile Cr.
Cape Gregory
Coquille River
Cape Blanco
Port Orford
Rogue River
Cape Sebastian
Statute Miles
OREGON
CALIFORNIA
Crescent City
Klamath River
Trinidad Head
Cape Mendocino
Pt. Delgada
Mendocino City
Pt. Arena Lt. Ho.
Base Line
Bodega Head
U. S. COAST SURVEY
PROGRESS OF THE SURVEY IN
SECTION No. X
(Upper Sheet)
FROM TOMALES BAY TO THE OREGON LINE
Scale 1/600,000
1875
Statute Miles

No. 20


U. S. COAST SURVEY
Sketch K
SHOWING THE PROGRESS OF THE SURVEY
IN
SECTION No. XI
(Upper Sheet)
FROM TILLAMOOK BAY TO THE BOUNDARY
From 1851 to 1875
Scale 1/600,000
1875
NOTES
A. Signifies Astronomical Station
M. do. Magnetic do.
T. do. Tidal do.
X do. Current do.
do. Lines between Primary occupied Stations
do. do. do. do. do. and unoccupied Stations
do. do. do. do. unoccupied Stations
do. do. do. Secondary occupied Stations
do. do. do. do. do. and unoccupied Stations
do. do. do. do. unoccupied Stations
do. do. do. Tertiary occupied Stations
do. do. do. do. do. and unoccupied Stations
do. do. do. do. unoccupied Stations
do. Limits of Topographic Sheets
do. do. Hydrographic Sheets
Vertical figures designate the number of Topographic Sheets
Inclined do. do. do. Hydrographic Sheets
The dotted shore line is unsurveyed
VANCOUVER I.
PACIFIC OCEAN
WASHINGTON
OREGON
FUCA STRAIT
Boundary between U. S. and British Columbia
Mt. Baker
Mt. Constance
Cape Flattery
Tatoosh I.
Pillar Pt.
Port Angeles
Destruction I.
Olympia
Pt. Nisqually
Seattle
Coweman
Carroll's Pt.
Drays Mt.
Goble's Pt.
Kalama
A.1873
Tillamook or Saul Rock
Saddle Mt.
Survey of COOS BAY OREGON
Statute Miles

Nº 21.


U. S. COAST SURVEY
Explorations in Alaska
By the Party under the direction of
W. H. Dall, Assistant.
1874.
ALASKAN MOUNTAINS
BEHRING SEA
NORTH PACIFIC OCEAN
KUSKOQUIM BAY
BRISTOL BAY
SHELIKOFF STRAIT
FAIRWEATHER GROUND
ELIAS ALPS
Unexplored
Great Plain
Blue Mountains
DIXON SOUND
Mt Wrangell
Mt St Elias
Mt Fairweather
Cape Sucking
Cape Clear
Middleton I.
Augustin I.
Iliamna Pk.
Trinity Is.
Chirikoff I.
Semidi Is.
Sutkwik I.
Cape Trinity
Mt. Chiginagak
Cape Stroganoff
Unalashka
Akutan
Bogosloff I.
Sannakh Is.
Cape Ivanoff
St Paul
St George
Pribiloff Is.
Nunivak I.
C. Avinoff
C. Newenham
C. Constantine
Kulukak Bay
C. Douglass
Barren Is.
Marmot I.
C. Greville
C. Barnabas
Sitkalidak I.
C. Spencer
Chichagoff I.
Admiralty I.
Prince of Wales I.
Coronation I.
C. Ommaney
Wrangell
English Factory
Ft Selkirk
Ft Francis
Indian Vill
Indian Village
Leather Vill
Kusilvak Mt.
C. Dall
C. Whymper
C. Romanzoff
C. Smith
Statute Miles
Nautical Miles
175°
170°
165°
160°
155°
150°
145°
140°
135°
130°
125°
60°
55°